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THE APRIL SCIENTIFIC MONTHLY

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Published for the

AMERICAN ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE

SMITHSONIAN INSTITUTION BUILDING, WASHINGTON, D. C.

by THE SCIENCE PRESS

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Karl Pearson. E. S. PEARSON. Illustrated. vii + 170 pp. $3.75. Cambridge University Press.

The author presents a study of the aims and methods of the life and work of his father, the eminent English biometrician. In the two Appendices appear the syllabuses of a great many of Pearson's lectures on Geometry Statistics, the Laws of Chance and on the Theory of Statistics.

THE SCIENTIFIC MONTHLY

APRIL, 1939

HUMAN NEEDS AND SOCIAL RESOURCES

By Dr. C. MACFIE CAMPBELL

MEDICAL DIRECTOR, BOSTON PSYCHOPATHIC HOSPITAL; PROFESSOR OF PSYCHIATRY, HARVARD UNIVERSITY

MENTAL health is the concern not only of the medical scientist and practitioner, and of the other scientists dealing with man as an individual and in his group relations, but is the concern of every citizen.

In this paper I propose to comment on various topics within the field of mental hygiene, hoping that the discursive nature of my remarks will not obscure the main theme, *viz.*, "Man and His Needs."

The recent symposium on mental health, sponsored by the American Association for the Advancement of Science, was an expression not of mere scientific curiosity, but also of grave practical concern, perhaps even of a certain impatience. In face of material difficulties and of the ravages of disease, man in the past appealed to his gods; modern man turns to the scientist. The scientist has responded to the appeal. He has given to his fellows control over the forces of nature to a degree undreamed of even by our grandparents. He has achieved signal triumphs over the forces which threaten the health of man. He has curbed the ravages of infectious disease, such as smallpox, typhoid fever, diphtheria. He has traced those subtle components of man's diet in the absence of which thousands have perished from scurvy, pellagra, beriberi. He has multiplied procedures for the prevention and cure of disease. The diabetic and the anemic resume efficient lives, radiant energy is harnessed for healing purposes; anesthesia has made surgery painless, asepsis has made it safe. The laity eagerly welcomes and applies each new medical discovery that promises immunity from disease, relief from pain; with individual exceptions—anti-vaccinationists exist, some people refuse to eat their spinach.

With such triumphs as the aforementioned in the field of general medicine, what steps are being taken towards the conquest of mental illness which strikes at the very core of the human personality? What progress is there to report in this field? At first sight the facts are disconcerting; statistics record no decrease in the total number of those suffering from mental disorders, they record an increase in the number of those admitted annually to the mental hospital. The taxpayer groans under the economic load of to-day, looks forward uneasily to the increasing burden of to-morrow.

In situations of difficulty personal discomfort is partly alleviated by transferring the feeling of personal responsibility to external objects; the scapegoat—an animal with a long and interesting history—is not yet extinct. In the present case a scapegoat may be found in the group of medical scientists and practi-

tioners, who are specially occupied with the study and treatment of mental illness. If one could transfer all responsibility to them, the conscience of the lay community and of the general medical profession might remain at rest. But the dominant consideration at present is that of constructive work, and of the respective contributions which can be made to such constructive work by the lay community, various special sciences, the general medical profession and the psychiatric group. It is in the interest of such constructive work that the symposium was held; its keynote was the desire to understand more clearly the nature and extent of this important medical and social task.

In the symposium one took stock of the situation, outlined facts, considered procedures. One may also have to outline goals. The goal in this field of medical work may be to help people to live *well*, not merely to safeguard them from external dangers; it may be to help people to put forth effort more *wisely*, not to help them to get along more easily. In talking of living well and wisely I realize that I am getting into deep water. My defense is that life is in deep water, that it is in the deep water of human life that mental disorders develop. If we are to help our fellows in their lives we must take some risks, and forego the solid support of a purely intellectual structure; life is more than science, it is an adventure of the spirit with nothing absolute and guaranteed. In face of our mental patients we have to deal with life in all its fulness.

The Scientist and the Study of Man

The symposium dealt with mental health, the health of the individual human personality as judged by its internal equilibrium and its adaptation to the physical and cultural forces surrounding it. Many groups of scientists deal with man. The physiologist gains ever deeper insight into the physical and chemical processes of the bodily tissues, into their integration and their adaptive significance. The social scientists investigate the social setting in which the life of the human individual runs its course. They make a systematic study of the various groups of which the individual is a member, and whose influence is an integral part of the individual's personality. They study the facts of family life, economic life, industrial life, political life, and the associated customs, traditions and institutions. They study individual man and human culture throughout their evolution in history. They make comparative studies of the various cultures of modern man, his crafts, his domestic and social habits, his beliefs and rituals. With their rich harvest these scientists have deepened and broadened our conception of man, so that in a discussion of man's mental health the terms we use involve a tacit reference to these gains even when the latter are not explicitly referred to. Scientists from diverse fields, as well as physicians, contributed directly to the symposium—biologist and physiologist, psychologist, economist, sociologist, statistician, anthropologist, political scientist, administrator, lawyer, pastor. They brought to the discussion data and conclusions gained in their special fields by their own methods.

The collaboration of the scientist in the field of mental hygiene may be not without its own reward. The study of the human personality from the point of view of mental hygiene may contribute something to the thought of the physiologist and of the anthropologist, of the economist and the sociologist. Scientists working from different angles on the same material establish a common frame of reference somewhat broader and more adequate than the narrow frame of reference to which the individual sciences seem to restrict the specialized worker.

This development of a broad frame of reference through scientific collaboration between different disciplines may be of special value when, as is sometimes the case, the scientist becomes philosopher. He is then apt to step outside of his familiar frame of reference and without revision of his categories to present us with a rather startling view of the universe; his prestige as a scientist may then give undue weight to a rather one-sided philosophy.

To those scientists who have not taken human activity either in its individual or group manifestations for their object of study, the analysis of the human personality has, too, a certain importance. For even where man as object is not of importance, man as subject has to be taken into account. The scientist, a human being, enters as observer into every observation. To the scientist, therefore, man presents a dual interest, as part of the cosmos and as an instrument of observation. As he scrutinizes his apparatus, recognizes its limitations, measures carefully its possibilities of error, so he must make allowance for his own limitations. He is an instrument of very complex structure. The astronomer, in making an accurate observation of time, makes allowance for his own personal equation, the slight distortion for which he himself is responsible He thus does justice to the fact that the world of his observation has a certain subjective quality. The scientist may find on examination that this subjective quality reaches further than he thought. He may become aware of unsuspected subjective factors which determine the trend of his interests in research, influence his observations and his conclusions. He may note with Charles Darwin that any facts and thoughts unfavorable to his own results are more apt to escape from memory than favorable ones. He may be chagrined to realize that his insistence on certain scientific formulations is partly determined by unacknowledged jealousies and antagonisms. He may wonder whether the unusual emphasis on precision and detail on which he has prided himself as a virtue may be after all in part a neurosis.

So in the specialized field of intellectual activity of the individual scientist, unrecognized elements in the personality may intrude. The scientist in alarm may wonder how far in his general philosophy of life and in his daily scheme of values these same elements play a part. Even to him mental hygiene may have a practical message. It is time, however, to discuss the general state of affairs, to discuss problems, men, methods, money.

The Field of Mental Hygiene

To introduce the topic of mental health by discussing mental illness is somewhat misleading. Mental health is more than the absence of mental illness, it is the condition in which the individual attains a certain internal equilibrium and adequate self-expression, utilizes the fulness of his endowment, has a moderate feeling of well-being or joy, makes his contribution to the life of the community. Merely to rub along in a way which attracts the attention of nobody and without any gross personal dissatisfactions is a poor standard of mental health. We must not be content with the physical status of a listless and undernourished child on the ground that he has no recognized type of physical disease. We must not be content with the mental health of a community where opportunities for artistic and intellectual satisfactions, for group activities and recreations, are negligible and where the individual lives a narrow and stunted life.

Our conception of mental health should be positive and constructive, but the crude facts of mental illness stare us in the face, make immediate demands, give us food for thought, teach us many lessons. We find that there are almost half a million patients in the special hospitals

of the United States suffering from overt mental illness, an uncounted number of patients with similar illness living in the community, a still larger number of patients with disorders of the personality which masquerade as physical invalidism, nervous troubles, asocial behavior. To care for the overt cases of mental illness (or "insanity," to use the legal term), many states have made systematic arrangements as adequate as the financial resources and the level of public opinion allow; other states have left the care of these patients to county organizations, while in still other states no definite plan of provision for the mentally ill has been formulated.

As Dr. Thomas Salmon, the first medical director of the National Committee for Mental Hygiene, said some years ago, "Every stage in the long and painful history of the care of the insane can be actually witnessed in some American community this afternoon." There are some public hospitals for the mentally afflicted which compare favorably with any general hospital; there are others where the patients are herded together under conditions which outrage the dignity of human nature. It is only yesterday as human affairs go, 1917 to be exact, that Salmon wrote his poignant account of the provision for the insane in a county poor farm: "In these cages, abandoned to filth and unbelievable misery, lie the insane poor of this pleasant, fertile, prosperous American county. . . . All of those distinctions which elsewhere govern the lives of human beings are merged in common degradation here." More recently (1937) in a careful survey of this field Deutsch has written: "There may still be found in the United States districts where the treatment of insane persons in jails and poorhouses is as inhuman as that which Dorothea Lynde Dix witnessed nearly a hundred years ago." These are not pleasant facts but have to be faced if we are making an honest study of social pathology.

Against this dark background of ignorance and neglect there stands out in sharp relief the enlightened attitude of many states where a central bureau or department, directed by competent experts, surveys the whole field, estimates the needs and the resources of the state, scrutinizes budgets, chooses carefully and supports loyally the physicians who direct the hospitals and their extramural activities. In the provision of hospitals for other forms of illness private philanthropy plays a preponderant rôle; but for mental illness there are in the whole country scarcely a dozen analogous hospitals supported by endowment or voluntary contributions.

The organization of a mental hospital and the rôle which under suitable direction it may play in the mental hygiene of a community were reviewed in the symposium. The efficiency of a mental hospital depends upon its personnel and upon its appropriations. Both these factors are intimately related to the life of the general community, to its economic life, its interests and code of values, its cultural and ethical standards, its political morality. The work of the state mental hospital is not an isolated function of medical science, practice and administration; it is a social function to which the physician can only contribute his individual endeavor. In seventeen states political considerations determine the appointment and tenure of office of medical superintendents and, in some instances, of all other persons employed in the state hospitals. Often physicians, *horresco referens*, without any suitable qualifications in the way of training or experience are appointed superintendents on account of their political services or personal contacts. The standard of medical care and research in a large number of hospitals is determined not by the status of contemporary medical science, but in part by predatory politicians trafficking in human misery.

The medical man may have therefore

to wage war against disease on two fronts; while carrying on his professional work to the best of his ability, not infrequently he has to reckon with the antagonism and disloyalty of those who should be his allies in the fight. He is apt at times to judge severely those who thus thwart and fail to support him. He may, however, in the light of his professional training, prefer to understand than to judge. With the help of the sociologist and the political scientist he may study the predatory politician and the conditions which produce him; he may study the legislator to find out what personal and social factors determine his attitude towards the claims of the mentally afflicted. In studying the electorate which has failed to play its part in correcting abuses or in backing improvements not only the political scientist, but also the cultural anthropologist, the sociologist, the economist and the educationist must come to the aid of the physician.

Even under favorable social and economic conditions the administrator of the mental hospital has a complex task, in carrying out each phase of which he finds himself acting within the definite limitations imposed by broader social factors. The professional training and outlook of his medical associates have been largely determined by the medical schools; the latter are deeply influenced by the contemporary currents of scientific and philosophic thought. The selection and training of nurses and other ancillary workers is affected by social attitudes and economic influences.

It is as one unit in this complicated social system that the physician with his own individual endowment and past conditioning, with his own professional equipment and philosophy of life makes his contribution to the study and treatment of the patients under his care. He faces the problems of diagnostic, curative, preventive work, tries to answer impatient demands for relief from an economic load, for some assurance that a devastating disease is at least under control.

In view of the wide-spread knowledge of the importance of mental illness as a medical and social problem, one would expect the community to respond here as it has responded to the challenge of other diseases, *e.g.*, of tuberculosis or cancer. One looks for a similar cooperation in the fight against mental illness, for well-equipped research institutes, for endowments commensurate with the complexity of the problem, for the interest of philanthropists, for the serious cooperation of the medical schools, for an adequate number of research fellowships, for the eager enlistment of well-trained medical graduates. With deep gratitude to those who have given serious support to the warfare on mental illness, one must still admit that the funds available for personnel and equipment are strikingly disproportionate to the magnitude of the task. Prejudice disappears slowly; surface appearances repel from close contact; dramatic success and quick returns can not be honestly promised; the difference between the problems of mental illness and those of bodily ailments is little realized. Medical science has gained its prestige from the study of the simpler functions of the human organism; the study of the more complex functions, those on which man's happiness, his efficiency and his human value depend, is frequently looked on askance by the medical scientist, and the younger generation is deeply influenced by the attitude of its teachers. So long as he is willing to work on the simpler functions of man with the precise methods adapted to their study the promising student will receive enthusiastic encouragement from his teachers, and can look forward to continued research under the most favorable conditions. When he proposes to study the human individual with special attention to his more complex functions, he will receive

encouragement from few of his teachers and must be prepared to prosecute research under much less favorable and more austere conditions.

Mental Illness

What is mental illness? What are those disorders to which reference has already been made? Can one state briefly their salient features, and give the layman an inkling of their significance?

The layman is inclined to think in terms of "the insane," and in that legal or administrative term with its residue of traditional associations all that is truly human and individual is apt to be lost sight of. The statutory endorsement by the court of the need of hospital treatment is a useful procedure in exceptional cases, but as a rule is a superfluous and disturbing procedure with which one would gladly dispense. Many patients with mental illness do not require hospital treatment. In many cases the symptoms do not betray their complex origin, and the patients complain of bodily symptoms, or of nervous symptoms of one type or another. In many cases the mental disturbance expresses itself in disturbing social behavior, and the patient is considered a delinquent. In other mild cases the individual is not considered to be sick at all, either by himself or by others, and his inner dispeace may only show itself in traits of character which we allow to pass in our neighbors without comment or analysis, hoping that they will be equally charitable towards us. The trait may even be capitalized and placed on the credit side of the account. A surgeon may be none the worse for a mild degree of misophobia (fear of dirt), which would be a serious neurosis in a clerical worker; a neurotic emphasis on precision, embarrassing to a grocer, may be an asset to a chemist.

It is well for us first of all to get rid of the traditional attitude which places such a wide gap between the so-called normal and the mentally disordered. Our normality consists in the ability to maintain a conventional surface so that our neighbors, perhaps we ourselves, do not have insight into the underlying forces at the basis of our moods, our interests, our behavior, our code of values, our attitude to the universe. Personality is etymologically derived from *persona*, the mask put on by the actor for the benefit of spectators. In mental disorders of a certain degree of severity the mask is broken and we see revealed the processes of human nature and are intuitively repelled.

We do well, however, as in other forms of sickness, in cases of ulcers, wounds, leaking hearts, faulty lungs, to control our intuitive reaction. When the physician interested in the sick person studies the offensive ulcer, the impaired circulation or respiration, and passes beneath the surface appearance he is plunged into a dynamic problem of the utmost complexity, of the greatest fascination. He finds revealed the subtle capacities of living material, dealing with stresses of the most varied description, and he becomes lost in the absorbing study of the forces involved. Pathologist and clinician alike are apt to talk in terms of esthetic rapture about the unusual beauty of material which to the uninitiated is displeasing and offensive. The intuitive reaction to the morbid and unusual is of brief duration in presence of curiosity as to the processes at work and of the eager hunt for general underlying principles.

If this be so in the face of bodily ailments, it is equally true with regard to disorders of the personality. Eager investigation replaces distaste and avoidance. With this new attitude in face of a mental patient, instead of seeing a human wreck, alien and unintelligible, separated from us by a deep abyss, we now see a particular instance of our common human nature dealing with the familiar issues of human life. The

patient comes very near to us; the story in many of its phases is our own.

Thus the desire to understand, the going beneath appearances, the tracing of the underlying forces of human nature help to develop an attitude to our patients and to our fellows which is in striking contrast with our intuitive reaction which we so seldom take pains to correct. A psychiatrist may occasionally have the opportunity to observe his own change of attitude towards an acquaintance. The latter considered as a social acquaintance may appear insupportable; as a patient with a human problem he becomes a fellow being of value who strikes a sympathetic note. If the psychiatrist could only maintain towards his acquaintances and colleagues the same attitude as towards his patients he would be a model of tolerance and patience. I suspect that a dinner party is rather complicated by the presence of a psychiatrist among the guests. He is suspected of looking on his fellow diners as he does on his patients. The suspicion is true. But if he does look on his fellow guests as he looks on his patients, it is because he looks on his patients as fellow mortals, as friends and colleagues of the same stuff as himself, facing the same human problems as himself, only making rather heavy weather of the actual life situation.

Coming back from one's acquaintances and oneself to the patients of a mental hospital—not such a violent jump, after all—one must first recognize the great diversity of conditions with which patients are afflicted. In discussing the ordinary run of bodily diseases we do not think in terms of some general "somatopathy," but in terms of the various special types of disease. Let us not blur the outlines of concrete experience in the present field by thinking in terms of a composite picture called "insanity." It may be necessary occasionally to use the general term insanity, but it is well to keep always in mind that one is dealing with human individuals in difficulty.

I may perhaps be allowed for the sake of this discussion, and with many qualifications, to divide mental illness in general into mental diseases and mental disorders. By *mental diseases* I mean those forms of mental illness where the physician finds evidence of underlying structural, toxic or nutritional damage to explain the disturbed behavior, thought or feeling of the patient. By *mental disorders* I mean conditions where no such unequivocal evidence exists.

Mental diseases in the above sense furnish the lesser half of the patients admitted to mental hospitals. In these patients the disordered behavior and thought are secondary to infections, to disorders of nutrition, to glandular imbalance, to disturbances of one or several organs or systems of the body. The problems of diagnosis, treatment and prevention in these cases are to be solved by the same methods as in the case of physical ailments in general.

Continuous progress has been made in our knowledge of these diseases, but the unsolved problems are many and await the eager mind, well trained and well equipped. The symposium emphasized many promising lines of investigation. Specially notable has been the increase of our knowledge about mental disease due to syphilis of the brain and to the abuse of alcohol. Here again one must refer to the responsibility which devolves upon the community. These forms of mental disease are preventable; together they represent a great economic loss and disrupt many homes.

Medical science has supplied the community with the requisite technical information in regard to mental disease of syphilitic or alcoholic origin, but the community shows little eagerness to utilize it. To utilize this information for the establishment of a more wholesome and efficient community life means a certain degree of enlightenment, a certain seriousness of purpose, a response to social needs, a willingness personally to

exert self-control and to limit self-gratification, an ability to free oneself from domination by group influence and familiar traditions. Prevention of these diseases is not a matter of enforced sanitation, but of continuous education. The medical profession has the responsibility for making as precise as possible the physiological results of alcoholism and of the consequent malnutrition and their influence upon the higher functions, and also the responsibility for studying the balance between the needs of man and the available resources for the satisfaction of these needs. The problem in the case of the alcoholic patient is in part to see what can be done to make life worth living for the individual. The solution depends in part upon social attitudes and organization, upon wages and upon housing, upon marital relations, upon religious beliefs and affiliations, upon the opportunities for recreation and self-expression. Similarly the problem of syphilis is not merely a bacteriological problem; it is one aspect of a major social and cultural problem.

A very different situation faces us when we take up the study of *mental disorders* in which we have so far no unequivocal evidence that there is a primary disturbance of any of the bodily systems. The physician may stand by an ancient dictum that all mental disorders are brain disorders, and hope that some day in the distant future the more thorough physical, chemical and physiological study of the brain will explain the attitude of man towards the universe and towards the demands of his social life. A more sound attitude is to study accurately the facts of human life and, while utilizing all that the biochemist and the neurophysiologist can teach us of underlying mechanisms, to keep in mind that these activities go on as the partial activities of living people, of people with warm emotions, vacillating purposes, partial insight. There is no *à priori* reason why we should discard the familiar facts of our personal experience and of our daily observations. We may of course for the purposes of physiological study provisionally discard these aspects of the living individual. In so far as we do discard them we are studying abstract processes, not the human individual who has a personality as well as a digestion.

The physiologist has contributed much to our knowledge of the emotional life. He has revealed to us by his ingenious experimental investigations the detailed processes of highly adaptive nature which form part of an emotional experience. The fact of the emotional experience, however, remains an equally solid datum of experience. The rôle which emotional factors play in the interplay of forces in the human personality has also to be studied. If we are interested in human nature and in interpersonal relationships we shall still have to use the term emotion, but that term will include all that the physiologist has taught us. He has enriched the meaning of the terms we use, deepened our insight into the workings of human nature, revealed to us details of the human organism hitherto unknown or obscure; he has thrown light on the symptoms of our patients, given help in their treatment.

In *mental disorders*, as above defined for the purpose of this paper, the constitutional vulnerability of the patient plays a rôle, but the influence of the environment must not be neglected. From infancy the environment begins to place its stamp upon the individual; throughout his life it makes continuous demands upon him. The study of an individual, which ignores his organic connection with the group, is the study of an abstraction. His childhood behavior is behavior in the special atmosphere of the home and of the school, and his personal development goes on as part of the development of a series of interpersonal relationships. In later life we see him in his occupational

setting, in the setting of the economic system, in a social system in which racial, religious and caste influences play upon him, enter into and are reacted to by his personality. It is in this complicated dynamic system that the individual lives his life.

We have already referred to contributions made by the sociologist, the economist, the cultural anthropologist. The psychiatrist in dealing with his individual patient is deeply indebted to these scientific colleagues, he has woven their contributions into the texture of his thought, enriched the connotation of his terms with the material they have supplied. His own special field, however, remains that of the study and care of the human individual in difficulty; the personality of the individual is the focus of his interest, and the human personality can neither be resolved into a physiological system nor dissolved in a system of interpersonal relationships.

Four Patients

So the physician, enriched and stimulated by workers in many fields, comes to his task, to the study of the human personality, of its needs and its difficulties and of the resources at its disposal. To illustrate these difficulties I offer a few fragmentary observations. I choose them from the more severe types of mental disorder and do this for the following reason. There is a growing recognition in the medical profession that the patient himself, the total organism, the human individual with all his personal difficulties, requires the same systematic study as the various organs and systems of the individual. There is, however, a tendency to give rather exclusive attention to the minor disorders, those disorders which do not estrange the patient from his fellows and from his physician, disorders which can be studied under the familiar conditions of medical observation. Granted that this is a very important field of medical work, which yields a rich harvest, there is a certain danger that this more elegant branch of psychiatry may be cultivated to the neglect of a psychiatry which faces the crudities of the more severe disorders, which have to be studied under the conditions which the disorders themselves allow. I can not forget the appeal of that half million of our fellow beings in mental hospitals whose crying needs are often so sadly ignored by the community and so inadequately met by the medical profession.

A childless Jewess, middle-aged, in poor economic circumstances, distresses her husband, her neighbors and a physician by fantastic stories; she claims that years ago she had a child, several children, and she runs around the neighborhood seeking to identify her imaginary first-born, now a lad in his teens. She later claims to be a person of high descent.

Behavior and beliefs pathetically incongruous with the actual facts; not to be explained in terms of tissue disorders, but in terms of individual human nature desperately striving to attain some sort of equilibrium in the face of unassuaged longings and prolonged deprivations. When life in its stark reality is no longer tolerable, man has still the resource of phantasy and of belief. The needs of the average individual may be adequately met by those beliefs which are common to the group, a cultural heritage, the product of a slow evolution. In face of her special needs this childless woman reached out for individual beliefs, which, however, could not be reconciled with the conditions of community life. Her personal inability to maintain her mental balance must be studied in its social setting. One must pay due attention to the family influences in her childhood, the social forces which conditioned her sex life, the racial attitude towards sterility, the limitations of recreation, friendly intercourse, supporting beliefs, the pres-

sure of economic circumstances. Each factor takes us beyond the isolated individual, indicates topics for research, suggests possibilities of melioristic social procedures.

A skilled craftsman invented some very ingenious toys which might be used as fire-lighters, also in his own words as "agents of the social revolution." The police found his room full of chemicals useful in the manufacture of explosives; also some pretentious manuscripts dealing with the difficulties of matrimony. An ambitious lad somewhat hard of hearing, he had been frustrated in his desire for an education; he had compensated by discursive reading and by the use of high-sounding words. Ungainly and unattractive to the other sex, he had learned to dance, hired his partners; in dancing he made up for lack of grace by rapidity and endurance. His unassuaged craving for personal distinction had led to pretentious authorship and to the idea of gaining prestige through the value of his inventions to a potential social revolution.

The many valuable assets in this man's endowment had found little encouragement at home or in his social environment. His history may throw light on the development of many a revolutionary leader. The economist and the historian may help us to compare the cost of a constructive program of mental hygiene with the expense in blood and treasure of one ill-balanced revolutionary leader.

In a mental hospital a young woman was much irritated by the nurses when they raised her shoulders in her bath; she talked with envy of Henry Ford. She had been brought up in a home of discord; her ambitions had been frustrated. Her great preoccupation was peace; she envied Mr. Ford not for his wealth itself, but because it enabled him to send a peace ship to Europe; the irritation with the nurses was due to their rumpling her wings, she was "the dove of peace."

Another young woman of prudish and reserved nature complained that people were taking an undue personal interest in her; they wanted to make her into Cleopatra, Helen of Troy, a savage woman, various film stars of considerable notoriety, a statue of liberty; she had been our Lord on the cross. In her curious utterances the conflict between fundamental cravings and cultural restrictions found expression; the mental disorder seemed to represent the disorganized continuation of an inner conflict which had given her life its special stamp.

I have offered these fragmentary illustrations of human difficulties to give some representation in my discussion to the human individual. I have tried to bring home to the reader the fact that beneath utterances that are fantastic and unreasonable, and conduct that is inappropriate and perhaps offensive, there may lie the familiar conflicts of human nature.

On Beliefs

Among the problems frequently presented by patients is the problem of their unusual beliefs, and with them the physician must deal, however poorly equipped for the task he may feel. The beliefs are facts of observation, they are special aspects of the activity of the human personality, of the human organism adequately conceived. It may therefore be permissible to make a few remarks on this topic from the point of view of the physician.

Belief plays an important part in the lives of many patients, it plays an important part in the life of the ordinary man, it plays a part in the life of the man behind the microscope and the test-tube. Science takes its origin from human curiosity; belief takes its origin from human needs. It is one of the biological qualities of man that he seeks to know what things are, how they work and what is their significance or value. Science tells him with increasing minuteness of detail and with

expanding breadth of vision how things work and the nature of sequences. The scientist as scientist can give no hint of the significance of the total world of experience as conceived under the categories of his science. He, too, requires something that goes beyond his science. He is not a mere spectator of a cosmic process; he is a dynamic element in the total system. He has to play his part in the game, he too has to take risks, to wed a belief, to take it for better or for worse. The marriage of course may not be celebrated openly, may be kept secret, even denied. The man in the street has a naïve belief in the significance of things. He is not satisfied with some colorless system, the mere product of observation and intellectual elaboration. The world for him is neither the "ghastly ballet of bloodless categories" of the Hegelian philosopher nor a meaningless dance of buzzing electrons. It is a system permeated with spiritual forces or values.

The cultural anthropologist and the philosopher have much to tell us about belief and its varied expression through history, under different climes and in different races. The physician has to deal with it in his own crude way as a biological phenomenon in the setting of the life of the individual patient. He has to consider its rôle in favoring or disturbing the internal equilibrium of the personality and the relation of the individual to the cultural group in which he lives. He is interested in its genesis in the individual case; he studies its adaptive value. He may consider what resources there are in the individual for attaining a more wholesome system of beliefs, and what resources there are in the community for bringing, through the medium of beliefs, comfort and stability to the individual. Under favorable circumstances when life is going smoothly, the individual human being may reject the need of any special system of beliefs; he may claim that in the face of difficulties the only sound response is to put forth effort and modify the actual circumstances. Even the positivist philosopher, however, in the face of catastrophic circumstances, which on account of factors intrinsic or extrinsic can not be modified—in the face of bereavement, of crippling and incurable disease, intolerable social or economic situations—may only be enabled to carry on by the resurrection of discarded religious beliefs.

Man does not live by bread alone; spiritual vitamins may be as essential to the welfare of the human organism as those other vitamins at present so assiduously advertised. We must not confuse the living belief with the external wrapping of dogma, creed, ritual and institution. The latter may divide and destroy, but the living belief in the significance of this world and the individual life has to be looked on as a powerful force that binds men close together. There is a certain unity of belief, as there is a unity of science.

On Conflicts within the Personality

The reference to the case of the childless Jewish woman has taken us far afield, and suggested some remarks on beliefs. The prudish young woman may tempt us to make some comments on conflicts within the human personality. She claimed that other people were thrusting on her the rôle of Helen of Troy and of other notorious or exhibitionistic characters; she disclaimed any such personal desires. Murder will out; in our own dreams, and in the symptoms of nervous and mental patients, hidden desires, repressed memories, unacknowledged fears find disguised expression. The young woman unsuccessful in maintaining the repression of sexual preoccupations could at least disclaim personal responsibility; "they," unspecified outsiders, were responsible for the threat to her character. She exemplified the mechanisms of re-

pression and projection by means of which we remain blind to important dynamic factors in our own nature, while their potent influence distorts our picture of the outside world. Here again the cultural environment enters into the equation. The young woman's blindness to her own sexual urge was determined by the atmosphere in which she had been brought up, was the product of influences unconsciously and consciously applied since infancy. In any constructive program of mental hygiene one must consider by what methods and procedures children may be prepared most efficiently to meet in a wholesome way the task of sexual adaptation, and what personnel and centers of influence are available for this purpose. The task is one which has not yet been faced, either by the community at large or by the medical profession, in an enlightened and unembarrassed way.

Life is a continual succession of decisions between conflicting tendencies. These conflicts are the special problem of mental hygiene; abnormal behavior, moods and beliefs are to a large extent the expression of conflicts unadjusted or unhealthily compromised. One can not both eat one's cake and have it. There is conflict between the various appetites. The juvenile in us conflicts with the grown-up, the egoistic with the altruistic, the imaginative with the realistic, one loyalty with another. As the individual matures, his hierarchy of values becomes more or less established, and decisions tend to be made according to this hierarchy and can to a certain extent be predicted; the more immature, the crude, the egoistic tend to be repressed under the pressure of the social code. Repressed trends do not necessarily atrophy and disappear, they may continue to lead a subterranean life beneath a conventional surface, they are liable to manifest their influence in traits of personality, in special interests, in our system of beliefs and code of values, in symptoms of mental and nervous disorder. The practical task of the psychiatrist is to help the patient towards a sound and sane balance between conflicting trends.

On Clothes

The above remarks have an important bearing on the scientific study of man as well as on the treatment of various disorders. The self-revelation which occurs in some mental disorders, and is achieved in others under treatment with effort and pain, offers a unique opportunity for the study of human nature, stripped of its customary coverings. To see man and his institutions in their stark reality is a rare acquisition. Professor Teufelsdröckh, whose mental twist led him to picture the most imposing court ceremonies with not a shirt on the participants, admitted that human imagination balked at figuring "a naked Duke of Windlestraw addressing a naked House of Lords."

Some persons might be aghast at a Who's Who in which the real individual appeared, stripped of his honors, degrees, official accomplishments and publications. This latter is the individual as seen in the consultation room. The physician therefore is able to furnish to our scientific knowledge of man a material which is unique, in which the needs, the resources, the mechanisms of the human personality stand out with unusual clearness. Some may refuse the term science to this body of knowledge acquired in the consulting room. This refusal is somewhat doctrinaire, but one must admit that the knowledge is gained under special circumstances and is difficult to formulate. The atmosphere of the consulting room is not the serene atmosphere of impersonal objective observation; it is an atmosphere charged with personal forces. One human being in distress appeals for help, another responds to this appeal of his fellow; a most unfortunate situation from the point of view of scien-

tific observation. The compensation lies in the fact that in the professional situation, in the face of issues of life and death, complete honesty may be at last attained.

On Methods

A difficulty with the material is that there are so many variables; systems can not be separated, concepts are difficult to define, are seldom scientifically pure. Instruments of precision appropriate to the most important factors are not available. One might also claim that experimental procedure is rarely applicable. In a certain sense this is true because the investigator dare not experiment with the fundamental issues of life. In another sense our patients present a unique experimental material. They are human beings with whom nature has carried out the most drastic experiments, acute and chronic. The investigator, however, has to wait until nature chooses to make these experiments; he can not determine their conditions; he can not rapidly accumulate material; he has to wait patiently and utilize eagerly the material which nature supplies, alas, too lavishly.

In the absence of the strict experimental method the investigator resorts to the statistical method, but here the large number of variables, the difficulty of defining terms and of precise measurement, the intimate relationship between the individual and the social group impose strict limits. He is, therefore, thrown back upon the biographical method. His task is very largely that of carrying out biographical studies with the utmost precision which the material allows. The biographical method is not unknown in other fields of science; biographical studies of the developing ovum and of various tissue cells have their own value, even when not reinforced by the experimental method. The biographical study of a tribe or of a nation may have to proceed without the help of experiment. The scientific biographical study of human nature is not to be identified with ordinary biography which seldom proceeds far beneath the surface, which is bound by conventional discretion with its reserves and reticences, which uses concepts with little precision. The biographical study of the human individual in the setting of the professional relationship discards convention, discretion, reticence. The terms which are used, although sometimes familiar and even colloquial, contain implicitly a reference to all that the basic medical sciences have taught us. The biography aims to present the real individual as he actually is and not to make him interesting in his appearance on the stage of history.

The Psychiatric Contribution to Our Knowledge of Man

The material so far accumulated is of value. The principles outlined in the light of this material may be looked upon as lacking precision; as first approximations they have great practical importance. It is dangerous to prefer very precise knowledge about unimportant detail to less precise knowledge about important issues. To avoid misconception one must of course emphasize the fact that no one can foretell when knowledge which at present appears of merely academic interest may become of great practical importance.

The physician, while engaged primarily in practical tasks, has as investigator been enabled to offer to his fellow scientists, studying man in his individual constitution and in his group relations, material which may with profit be incorporated into their concept of man. The physician has had to deal with the living individual; man of the other scientific disciplines is an abstraction or schema.

Man of the physiological laboratory is a most ingenious mechanism but lacks a soul. Man of the psychological laboratory is a highly respectable fellow, carrying out his simple tasks with docility, but

living a sheltered life, exposed to no human emergencies. Economic man, perhaps already extinct, was a curious fellow, bloodless and unemotional, moved by very few springs. As for the man of history, it was difficult to see him through his various trappings, his titles, his official exploits and the mendacity of his chroniclers. The data derived from the study of suffering man, neurotic and psychotic, may not only enrich the concept of man but may bring to special economic, sociological and cultural problems suggestions of theoretical and practical value.

The Needs of Man

In dealing with the needs and difficulties of his patients the physician finds that certain trends or cravings or needs recur with special frequency. The appetites claim their rights, pleasure is a directing influence, the sexual urge is of outstanding importance; man craves fellowship, friendship, affection, love; he craves a certain status or recognition from the group, a feeling of personal value, he suffers from a feeling of inferiority; he needs some reasonable opportunity for self-assertion, for the exertion of power and the expression of his individual skills and interests; he tends to see some orderly sequence in the flow of events; he tends to see the world as a system of values and his individual life as significant.

The Social Resources

In view of these fundamental human trends and cravings it is important to scrutinize our actual social organization and cultural atmosphere, to see how far these cravings can be satisfied and what difficulties stand in the way. One would like to see a thorough-going and systematic research into the organization of the home and of the school, of the factory, the store and the office, into the opportunities available in urban and rural communities for recreational and social activities, for self-expression and self-development in crafts and in intellectual and esthetic pursuits, and into the cultural codes and beliefs which permeate community life and give to the individual life its special significance.

The Next Step

The search for increase of knowledge and the practical application of existing knowledge to the demands of life are mutually profitable and stimulating. The limitation of existing knowledge is no excuse for failing to apply the knowledge already available. Meteorology may be a very incomplete science, but one does not on that account refuse to take a prophylactic umbrella. The progress of mental hygiene will depend on further research, but also on well-organized effort to disseminate existing knowledge and to embody it in actual procedures. The knowledge already available would if applied transform the lives of countless individuals and leaven the life of the community.

The field of mental hygiene is so extensive, so complicated, so interwoven with social and cultural issues that the cautious refuse its challenge, hesitate to engage their energies and their funds. Accustomed to simpler problems and procedures, which yield comparatively rapid and demonstrable results, they are impatient with results which depend in part on processes of social education and evolution, so much slower than measures of sanitation.

The challenge remains; fortunately the resources for meeting that challenge are already considerable. The medical profession is beginning to realize its special responsibility for the increase and dissemination of knowledge in this special field. There is a stirring in the medical schools which, it is hoped, will soon place this medico-social problem in its proper

place in the medical curriculum and in programs of research.

As for the systematic and organized application on a nation-wide basis of the knowledge already available experienced leadership is at hand. The National Committee for Mental Hygiene has for almost thirty years not only carried on an important series of surveys, but has throughout the whole country been intimately associated with the organization of regional activities. Its experience offers an invaluable basis for nation-wide plans.

The federal Public Health Service has recognized the place which mental health plays in the general field of public health, and can put its unequalled resources behind any constructive scheme. Several large Foundations have shown their interest in the field of mental hygiene, and have generously contributed to specific projects.

In several states there are competent state departments of mental health, supervising an efficient system of hospitals, each one of which is a regional center of mental hygiene, its activity radiating into the life of the community, integrated with many other social activities. In various states are scattered child guidance and other community clinics, working models capable of adaptation to communities of varied resources. The school system and the teachers' colleges are strategic centers of the greatest value. The executives in many large industrial and commercial organizations are deeply interested in mental hygiene. Beneath the hard-headed exterior of the president of a large financial or industrial concern there may lurk a sentimental humanitarian, just as the exterior of a modern scientist may conceal a medieval scholastic. Throughout the country there are countless enlightened and public-spirited men, with an unusual tradition of philanthropic support for humanitarian activities.

The resources for meeting the challenge of mental hygiene are by no means negligible; for their utilization one may need additional enlightenment, inspiration, organization and direction.

NATURAL HISTORY OF SANTA CATALINA ISLAND[1]

By Dr. T. D. A. COCKERELL

PROFESSOR EMERITUS OF ZOOLOGY, UNIVERSITY OF COLORADO

To any naturalist, the life of islands has a peculiar fascination. Here he may study the effects of the environment on an isolated fauna and flora, or may find, still surviving, types which have died out as the result of severe competition on the mainland.

We all remember how Darwin's visit to the Galapagos Islands caused his keen mind to reason about the origin of the insular birds and reptiles, and was the means of leading him to develop a theory of evolution. If there is any one now living who doubts evolution, and is at the same time willing to consider the evidence, the life on islands may be recommended to his consideration. He will see how remote islands have apparently been populated in various accidental ways, at long intervals of time, and how the colonists have multiplied and divided into numerous species, as shown by the snails, beetles and other invertebrates of many islands in the Pacific Ocean. These swarms of insular species, if one may so call them, are very conspicuous in the tropical Hawaiian Islands, but no less so in islands far to the south, such as Rapa, where the climate is warm temperate. In spite of the complexity of the subject, the main outlines are fairly evident, and should be convincing to those who will impartially study the evidence.

Wallace, in his classic book, "Island Life," described the different types of islands; those called continental, which were once part of a mainland, and those called oceanic, which rose out of the depths of the sea and were islands from the beginning. This classification can usually be made by a study of the fauna. The oceanic islands, for instance, have no native frogs or salamanders, or mammals other than possibly some bats.

My wife and I have at different times visited many islands, all different and deserving intensive study. As early as 1879 I went to Madeira, and again long after to Madeira and Porto Santo. These islands, out in the Atlantic east of North Africa, are especially remarkable for the extraordinary number and variety of land snails. At one time, I was curator of the museum at Kingston, Jamaica, a beautiful tropical island celebrated for its ferns and snails, its birds and butterflies. Not very many years ago, we visited New Caledonia, a large island in the South Pacific, which has an extraordinary flora with many peculiar plants, but a relatively poor insect fauna. The Hawaiian Islands, Samoa and Fiji have given us some undescribed forms of insects or snails as the result of brief visits. And finally, I must not forget the British Islands, where I was born and grew up. Wholly continental in type, they nevertheless have some special forms of life, even mammals, birds and fishes not known from elsewhere. It is difficult for a visitor to appreciate all these diversities, unless he has made a special study of the subject and has read the appropriate literature. It is indeed difficult for a resident, if he has not made comparisons and studied details. In quite recent years, rather numerous special (endemic) races of birds and mammals

[1] The flower pictures illustrating the article are by Mrs. Eugene M. Smith of Avalon. All the others have been kindly supplied by the publicity department of the Catalina Island Company.

VIEW OF AVALON,

THE ONLY TOWN ON ANY OF THE ISLANDS. IT IS A FAMOUS TOURIST RESORT, AND IS GREATLY OVERCROWDED IN THE HEIGHT OF THE SEASON, BUT DURING THE GREATER PART OF THE YEAR IT IS A VERY PLEASANT PLACE TO STAY, AND ONE MEETS MANY INTERESTING PEOPLE.

TREE POPPY,

Dendromecon harfordii OF KELLOGG; ONE OF THE MOST BEAUTIFUL ISLAND ENDEMICS. THE NAME OF THE GENUS MEANS TREE-POPPY IN GREEK. THE PLANT WAS DISCOVERED BY W. G. W. HARFORD ON SANTA ROSA ISLAND IN 1872, AND DESCRIBED IN 1873. THE SANTA CATALINA FORM HAS SOME DISTINCTIVE CHARACTERS, AND WAS CALLED *Dendromecon arborea* BY GREENE, MATERIAL HAVING BEEN COLLECTED IN 1896 BY MRS. TRASK. IT PROBABLY SHOULD STAND AS *D. harfordii arborea*. THESE BEAUTIFUL POPPIES ARE VARIABLE, AND IN NEED OF FURTHER STUDY. THE WHOLE GENUS IS CONFINED TO THE PACIFIC COAST REGION OF TEMPERATE NORTH AMERICA.

have been described from the British Islands, in spite of the long period before, when these creatures were familiar to resident zoologists, but considered to have no special peculiarities. It may be argued that when the differences are so slight as to almost escape observation, it is not worth while to distinguish them, but the biologist sees here the beginnings of the evolutionary process, and finds the very material he needs for the establishment of the theory.

When, in other cases, the insular endemics are so distinct as to strike the eye of any casual observer, it is not evident, without additional information, whether these creatures are really special to the islands or not. Thus we need brief illustrated guides to all the groups of islands, explaining, so far as may be, the significance of what may be seen.

My past interest in this subject makes it natural that I should be attracted by the problems presented by the eight islands off the coast of California. For the most part in plain sight from the mainland, they nevertheless have an extraordinary number of endemics, that is, forms restricted to the islands, found nowhere else. A former connection with the mainland is indicated by the presence of salamanders, and on the northern islands by the remains of an extinct

CROSSOSOMA CALIFORNICUM

(OR *C. californica*, IF WE FOLLOW THE LATIN RULE THAT ALL TREES ARE FEMININE). THIS TYPIFIES A DISTINCT FAMILY OF PLANTS, AS DESCRIBED IN THIS PAPER. IT IS A SMALL TREE, REMARKABLE FOR THE DELICATE BEAUTY OF ITS WHITE FLOWERS, AND THE CURIOUS FINGER-LIKE PODS. PEOPLE IN STA. CATALINA CALL IT WILD APPLE, BUT THE NAME IS INAPPROPRIATE. FINGER-TREE, FROM THE APPEARANCE OF THE FRUITS, WOULD BE BETTER.

species of elephant or mammoth, the *Archidiskodon exilis* of Stock and Furlong. No amphibia, such as the salamanders, can cross the ocean, and it can not well be doubted that the elephants came on dry land. Thus connection with the mainland, at some remote period, must have occurred. Geologists have postulated that, as late as Miocene times at least (between about 17 and 37 million years ago), there existed a large land area, including all the present islands, which were then parts of mountain ranges. This land has been called Catalinia, and it is supposed that it included San Pedro Hill, familiar to mainland Californians, which looks very much like another island when seen from Santa Catalina. Long isolation is further suggested by a very distinct kind of jay

VIOLA PEDUNCULATA,

THE YELLOW VIOLET OR PANSY COMMON ON GRASSY SLOPES. IT IS A COMMON SPECIES OF THE MAINLAND. NEAR THE WRIGLEY HOUSE ON THE CLIFF ABOVE AVALON I FOUND SOME WITH VERY LARGE FLOWERS, AND WONDERED WHETHER THERE COULD BE AN ISLAND RACE. BUT LATER I FOUND MANY PLANTS WHICH APPEARED TO DIFFER IN NO RESPECT FROM THOSE I HAD SEEN ON THE MAINLAND.

COREOPSIS GIGANTEA

OF KELLOGG, GROWING ON THE CLIFFS AND SLOPES AT AVALON. FLOWERS YELLOW, AND STEMS EXTRAORDINARILY STOUT, LIKE A SMALL TREE-TRUNK. I HOPED TO FIND A SPECIAL BEE VISITING THIS PLANT, BUT NOTHING OF THE SORT WAS OBTAINED. THE GIANT COREOPSIS IS ALSO FOUND ON THE COAST OF THE MAINLAND, AND JEPSON SAYS IT MAY ATTAIN A HEIGHT OF SIX FEET.

(*Aphelocoma insularis*) confined to Santa Cruz Island, where it is common. Assuming that this bird acquired its distinctive features after the island became separated from the mainland, we have some indication of the rate of its evolutionary development in the length of time that has passed during the last period of the latest geologic era. That is, the evolution of the jay must be supposed to have occurred during a part of the Pleistocene.

The question arises as to whether this former land area, Catalinia, extended down to Guadalupe Island, which is 135 miles southwest from Point San Antonio, Lower California. Guadalupe has no less than eleven of the plants which are otherwise confined to the California islands, and three of the snails, but there are no

RHUS INTEGRIFOLIA,
A VERY COMMON SHRUB WITH PINKISH FLOWERS, KNOWN AS LEMONADEBERRY. IT IS REALLY A KIND OF SUMAC. ON SAN MIGUEL ISLAND IT USED TO ABOUND, BUT HAS NOW D'SAPPEARED AS A RESULT OF OVER-GRAZING. THE GNARLED TRUNKS ARE STILL TO BE FOUND IN ABUNDANCE, AND ARE USED AS FUEL. ON PRINCESS ISLAND, OFF SAN MIGUEL, THIS SHRUB STILL SURVIVES.

land mammals. A bottle placed in the sea at Port San Luis, California, was recovered at Guadalupe Island 38 days later, showing that the currents are favorable. It had traveled about 400 miles, with an average speed of about 10 miles a day. Thus any floating object would reach Guadalupe Island quite easily, even under present conditions. In a paper to be published later, I have reviewed the Guadalupe problem, and contrary to my previous bias, conclude that the island is oceanic—that is, had no mainland connections. Its long isolation is indicated by the existence there of no less than nine kinds of endemic birds, seven of them regarded as distinct species. Three are unfortunately probably extinct, owing to the obnoxious behavior of man. This conclusion tends to sharpen our wits for the detection of means of transport across the sea, and requires observations which are often hard or impossible to make, the immigrants arriving so rarely, at long intervals of time.

Santa Catalina, about twenty miles south from San Pedro, seems to have subsided in the comparatively recent past, according to R. D. Reed.[2] The island is 18½ miles long, with a maximum width of 7 miles. The highest peak is 2,109 feet above sea level. The island is extremely rugged, with rocky slopes which, with their piles of ancient débris, indicate long-continued erosion. The recent heavy rains have resulted in many land-slides, blocking the roads, but these have been largely due to the operations of men, making steep banks when building roads.

On landing at Avalon, it is not necessary to go far to find some of the most interesting endemics. Flying around the Birdsfoot Trefoil (*Lotus*) one sees little brown butterflies, the hind wings with thread-like tails. These belong to the species *Strymon avalona,* entirely confined to this island. The related mainland butterfly, *S. melinus,* is found on Santa Cruz Island, as shown by a specimen collected by John Garth, in the collection of Don Meadows. There is a very deep channel between Santa Catalina and the northern islands (the deepest part over 700 fathoms) and it must be a very long time since they were united. Certain kinds of butterflies, such as the Painted Lady (*Vanessa cardui*) readily cross arms of the ocean, and reach the islands from the continent. But with other species this seems not to occur. Many species common on the mainland do not exist on the islands, in some cases owing to unfavorable conditions, but in others apparently because they have not been able to cross the sea.

Turning to the left on leaving the steamer, we soon come to the high cliffs

[2] "Geology of California," 1933.

below the Wrigley house. Here I discovered under rocks, years ago, the endemic snail *Micrarionta rufocincta beatula*. It has a small shell, with the margin of the aperture greatly thickened. I recently found it at Pebbly Beach, living under stones with ants. On the face of the cliff are large plants with stems as thick as one's arm, thread-like leaves and bright yellow daisy-like flowers. This species is *Coreopsis gigantea*, very characteristic of the islands, but not peculiar to them or to Catalina, as Holder stated.

Along the road at the top of the cliff, and in many other places here and there, we find a shrub with beautiful white flowers, facing downward, rather suggesting apple blossoms. The fruits are very peculiar, with finger-like follicles, rather suggesting a peony, one to seven in a cluster from a single flower. Locally, the young people call it wild apple, but this is quite misleading; finger-plant would be descriptive but not elegant. It is a plant to be regarded with extraordinary interest, not only for its delicate beauty, but because, with another species in the deserts of the Southwest, it represents a distinct family of plants. Our Catalina species is also found on San Clemente and Guadalupe Islands, and may well have been an inhabitant of the old Catalinia. Its botanical name is *Crossosoma californicum*, and it was described by Nuttall nearly 90 years ago from material collected by the ornithologist, Dr. Wm. Gambel. Such instances raise the question why a family of plants should thus be confined to such a limited area. It can not be doubted that it is of great antiquity, and one must suppose that it formerly occupied a much larger territory, though this is not certain. Perhaps fossil remains will turn up later. The two existing species seem to get along well in their present habitats, and it will take close and patient study to determine why they are not more wide-spread. I watched the *Crossosoma* on Sta. Catalina in the hope of observing its insect visitors, but did not see anything.

About fifty years ago Wm. S. Lyon explored Santa Catalina for plants, and found the remarkable tree which Asa Gray, of Harvard University, set forth as a new genus, naming it *Lyonothamnus*. This genus is entirely confined to the islands, except that it exists in cultivation, as at Santa Barbara. The trees, about 30 feet high, occur on Santa Catalina in steep gulches, and the flowers, which I have not seen, are described as white and beautiful. The flowering time is in June. The popular name is ironwood, which is unsatisfactory, because it has also been used for quite a different plant. The nearest relatives are the Spiraeas, of the rose family.

Continuing along the road to the left, on the board-walk by the sea, we come to the little settlement known as Pebbly Beach, where the pottery works were established. Turning the corner by the stone quarry, we soon come to a place where we see alongside the road some tall plants with long spikes of dark-colored

THE ISLAND QUAIL

DESCRIBED BY DR. GRINNELL AS A DISTINCT SUBSPECIES, *Lophortyx californica Catalinensis*. IT IS ABOUT 9 PER CENT. LARGER THAN THE MAINLAND BIRD, AND SOMEWHAT DARKER. THE BILL IS HEAVIER, AND THE FEET STOUTER. IN 1895 GRINNELL THOUGHT THE STA. CATALINA QUAIL HAD BEEN INTRODUCED, BUT IN 1906 HE CONCLUDED THAT THIS WAS NOT THE CASE. QUAIL WERE KNOWN ON STA. CATALINA AT LEAST AS FAR BACK AS 1859.

PICTURE TAKEN FROM THE SUMMIT,
THE HIGHEST POINT ON THE ROAD ACROSS THE ISLAND. FROM THE HIGH LAND ON STA. CATALINA ONE MAY SEE THE CALIFORNIA COAST VERY DISTINCTLY IN ONE DIRECTION, AND ON THE OTHER SIDE THE ISLANDS OF SAN CLEMENTE AND SANTA BARBARA. A FEW BISON HAVE BEEN INTRODUCED ON STA. CATALINA, AND WE SAW THEM NEAR THE SUMMIT, GRAZING.

flowers, the whole spike with long, glandular, silvery hairs. This is the figwort, *Scrophularia villosa*, peculiar to Santa Catalina and San Clemente. It is visited by numerous bees, *Emphoropsis depressa*, gray insects which fly rapidly, going quickly from flower to flower. In many cases the flowers are dependent on certain visitors for cross-pollination, and these visitors depend on the flowers for food. When this phenomenon (called oligotropism) occurs, the plant and its bees must migrate together, if at all. Thus in Colorado the long-tongued bee *Melitoma* is associated with the wild bush morning-glory, and is common near Denver, where the plant occurs, but quite absent at Boulder, where the plant is lacking. Why the distribution of the plant should be thus limited, I do not know.

Ten miles from Avalon, we visit Middle Ranch, and there find a peculiar groundsel, *Senecio lyonii* of Gray (another discovery of W. S. Lyon), which has tufts of white, wool-like material in the axils of the leaves, giving it the appearance of being infested by mealybugs. This plant occurs on Santa Catalina and San Clemente, but also on the peninsula of Lower California.

One of the most beautiful island endemics is *Eriophyllum nevinii*, which grows on the face of the cliff at Avalon, near the casino. This is a composite plant with yellow flowers and dissected

CAPE CANYON

A TYPICAL VIEW OF AN INTERIOR VALLEY, WITH LOW-GROWING OAK TREES. WE VISITED SUCH A CANYON (BULLRUSH CANYON) NEAR MIDDLE RANCH, AND FOUND THERE SOME INTERESTING INSECTS AND PLANTS.

silvery leaves; it deserves a common name, and indeed two names have been suggested, but both belong properly to quite other plants. I propose that it be called Catalina Silver Lace.

As we go along the road, dark-colored ground-squirrels constantly run across from side to side; these are the endemic *Citellus beecheyi nesioticus*, described by Elliot in 1904. The island has three other mammals all its own, a small fox and two kinds of mice. The existence of so many races of mammals on continental islands is an indication of the relatively rapid evolution of these animals, although it is true that the differences observed are usually not very profound. Since divergence can occur in all sorts of characters, physiological or structural, it is necessary to remember that the amount of difference can not always be estimated from the superficial examination of preserved skins. It is probable, however, that the insular races of mammals would for the most part interbreed freely with their nearest relatives, were they not isolated.

Still more conspicuous than these mammals are the quails, which constitute a special race (*Lophortyx californicus catalinensis*) of the California quail. Dr. J. Grinnell, of the University of California, who distinguished it, states that it is about 9 per cent. larger than the mainland bird and has a darker color. There was a question whether the quail had been introduced by man; it is known at least as far back as 1859, and is now be-

LITTLE HARBOR, SHOWING THE CHARACTERISTIC SHORE-LINE OF THE WESTERN SIDE.

lieved to be a true native. The quail on San Clemente was introduced, and is the ordinary mainland bird.

A very interesting case is that of the little humming-bird with reddish-brown tail, named *Selasphorus alleni sedentarius* by Grinnell. The mainland Allen humming-bird migrates to Mexico in the winter, but the island form, which Dr. Grinnell tells me occurs on Santa Catalina, San Clemente and Santa Cruz, does not leave. It is also larger, and differs in some details of coloration. The difference in the behavior of the humming-bird may be ascribed to the direct effect of the relatively uniform climate of the islands, with mild winters; or it may be due to a physiological peculiarity which has evolved on the islands and proved advantageous.

Mocking birds are abundant and resident. They are said to be lighter on the back than the mainland form, at least so far as concerns the birds of San Clemente, but no distinct race is recognized. A. B. Howell (1917) states that the life-cycle of the smaller birds on the southern islands is shifted a month or six weeks earlier than that of the corresponding mainland forms, the molt occurring earlier than on the mainland. I was interested to note that the large handsome bees (*Anthophora stanfordiana*), which visit the flowers of the loco weed (*Astragalus leucopsis*), on Santa Catalina are flying at the beginning of April, whereas Mr. Timberlake tells me they appear at Riverside in May.

I have in manuscript a revised list of the beetles of the islands, and find about 39 to be apparently endemic. These belong mainly to three families, and

especially to the Tenebrionidae, many members of which are large black ground beetles, unable to fly. The large number of endemic insects is of course a consequence of the numbers of species of these animals. Although there are many more endemic beetles than mammals, the island mammals are all more or less distinct, except the bats, whereas only a small proportion of the beetles is distinct. It is conceivable that in some cases endemic island insects may have reached the mainland, and so lost their endemic status. I have elsewhere given reasons for suspecting that this may be true of some of the plants. The smaller flying insects may be blown long distances by the wind. Thus A. C. Hardy and P. S. Milne (1937) report on insect drift over the North Sea. They obtained no less than 730 specimens, in some cases 120 to 150 miles from the English coast. Of all the island beetles, perhaps the most remarkable (because most distinct) is the *Eleodopsis subvestitus,* described by Blaisdell (1937). Nineteen specimens were collected on San Nicolas by J. R. Slevin in 1911; but they had an ordinary appearance, and were not for a long time recognized as peculiar. But Dr. Blaisdell, on recently studying them, found them so peculiar as to require the establishment of a new tribe, Eleodopsini.

The examples I have cited are only a few of the many rare or endemic plants and animals to be found on Santa Cata-

THE ISTHMUS,

THE NARROWEST PART OF THE ISLAND, WHERE MANY "SOUTH-SEA" PICTURES HAVE BEEN FILMED IN RECENT YEARS. THE ISLAND OF SAN CLEMENTE IS SEEN ON THE HORIZON. NOT FAR FROM THE ISTHMUS WAS THE HOME OF MRS. BLANCHE TRASK, WHO WAS LONG FAMOUS AS THE BOTANIST OF THE ISLANDS. FIVE OF THE ISLAND ENDEMIC PLANTS HAVE BEEN NAMED AFTER HER.

lina. No doubt the mammals, birds and flowering plants have all, or nearly all, been recorded; but among the insects there will be hundreds of additions to the fauna, when sufficient collections have been made and worked up. Mr. Don Meadows, of Long Beach, was a teacher in the high school at Avalon from 1927 to 1934, during which time he explored all parts of the island, collecting butterflies and moths. He has published a list (1936) of the Santa Catalina butterflies, 28 species. Of these, there is one endemic species, as mentioned above, and two forms of orange-tips have been recorded as endemic races.[3] The list of moths has not yet appeared, but I was recently permitted to examine the Meadows collection, and found over 170 species identified, and a good many others still to be determined.

A striking feature of the lepidopterous fauna is the absence of types common on the mainland. Thus the well-known butterfly *Euphydryas chalcedona* (the chalcedon checker-spot) is wholly absent, though its food plant is present. It exists on Santa Cruz Island, where it was collected by John Garth. Among the moths, the large silk-moths or Saturniidae are absent, and only four kinds of sphinx moths were taken.

In order to obtain true understanding of the life (biota) of Santa Catalina, it is necessary to consider both past and present, and to know both plants and animals, large and small. Such exhaustive knowledge is impossible for one individual, and the whole subject may appear too complex to be intelligible. Nevertheless, the broader features of the picture are readily appreciated, and can be understood by any intelligent person. The details are full of interest and lead us on to one discovery after another. Putting together what is already known, we have a large mass of ascertained facts, which can be arranged and compared. In the course of time, it may be possible to present the gist of all this in a book, which, if clearly written and well illustrated, will serve as a guide to those who would know something of the natural history of the island and a stimulus to those who would seek out the still unknown facts. In dealing with these matters, it is not sufficient to offer crude statistics, which may be misleading. I have in my possession (given to me by his son, Francis Darwin) an old manuscript of Charles Darwin's, in which the objections to statistical methods, without proper analysis, are well set forth. Darwin says: "If North America had no mammal identical with Europe, same way as South America has not, then the percentage system would not show that North America was incomparably closer allied in its mammifers than South America is." "It comes to this, that the percentage system takes no account of relationship of organisms, when all species differ. For instance, Galapagos *land* birds all different from South American, yet certainly closest alliance."

If these difficulties increase our perplexities and doubts, they also indicate opportunities for fruitful research, leading in some cases to results which could hardly have been anticipated.

[3] One of the latter was rejected by Mr. Meadows as not distinguishable, but he now thinks it may be accepted, though the characters are very slight.

BEHAVIOR AND SOCIAL RELATIONS OF FREE-RANGING PRIMATES

By Dr. C. R. CARPENTER

DEPARTMENT OF ANATOMY, COLLEGE OF PHYSICIANS AND SURGEONS, COLUMBIA UNIVERSITY, AND THE SCHOOL OF TROPICAL MEDICINE, SAN JUAN, PUERTO RICO

INVESTIGATORS interested in comparative studies of primate behavior have, during the past ten years, carried out a series of studies on selected types of primates in their native habitats. Henry W. Nissen did observational work on free-ranging chimpanzees in French Guinea,[1] and shortly afterwards Harold C. Bingham made a field study on the mountain gorilla in relation to its habitat in the Belgian Congo.[2] During the same period S. Zuckerman observed extensively the baboons of Monkey Hill in the London Zoological Garden and while collecting anatomical specimens, he did limited work on the free-ranging baboons in South Africa.[3]

Continuing the studies on free-ranging primates under the direction of Professor Robert M. Yerkes, of Yale, I spent the greater part of the time from 1931 to 1933 in studying the New World primates or platyrrhines, especially the howling monkeys (*Alouatta palliata*) on Barro Colorado Island in the Panama Canal Zone.[4] Extensive observations were also made on red spider monkeys (*Ateles geoffroyi* Kuhl) of northern Panama and Costa Rica,[5] on the capuchin monkey (*Cebus capucinus*) of Panama, on the squirrel monkey (*Saimira örstedii*) of northern Panama and on the Canal Zone marmoset (*Oedipomidas geoffroyi*).

These studies are part of a general program of field work on sub-human primates which has the stated objective of accumulating reliable and extensive data on a series of important, selected primate types living in their native habitats. This research work involves prolonged observations of all modalities of behavior, social relations, ecological relations and the use of every available means of getting accurate information on the life histories of the species selected for observation while they are living undisturbed in the environment which has given rise to the species.

Thus in the comparative studies of the behavior of monkeys and apes, a field in which there has been so much speculation, though it has been unduly neglected by scientists when its probable significance is considered, attempts are being made both in the field and in the laboratory to accumulate a sound factual body of information. It is hoped that this information on free-ranging animals will supplant the colorful tales of dramatic incidences told by sportsmen, hunters and travelers and embellished to make good adventure stories. The data may importantly supplement the sketchy and unreliable reports which have characterized the literature dealing with the life histories of man's closest living relatives in the mammalian series.

Professor Adolph H. Schultz, of the Medical School of the Johns Hopkins University, has for many years been making large collections of primate specimens, especially skulls and skeletons, in

[1] H. W. Nissen, *Comp. Psychol. Monog.*, Vol. 8, No. 1, pp. vi–122, 1931.

[2] H. C. Bingham, *Carnegie Inst. Wash. Pub.*, No. 426, pp. 66, 1932.

[3] S. Zuckerman, London, Kegan Paul, Trench, Trubner and Co., Ltd., pp. 357, 1932.

[4] C. R. Carpenter, *Comp. Psychol. Monog.*, Vol. 10, pp. 1–168, 1934.

[5] C. R. Carpenter, *Jour. Mammal.*, Vol. 16, No. 3, pp. 171–180, 1935.

THE RECORDING APPARATUS FOR GIBBON CALLS.
THE EQUIPMENT CONSISTED OF A PRESTO UNIT, TWO BATTERIES AND A TRANSFORMER GENERATOR.

order to ascertain intraspecies variations and to make possible comparisons of a wide range of primate types. Professor Schultz has found it expedient from time to time to go into the native habitats of selected primate types in order to have adequate numbers of freshly shot specimens for statistically significant series. In addition, these collecting expeditions have yielded much relative to reproductive phenomena and embryological development.

The Asiatic Primate Expedition

A group of scientists returned to the United States, in September, 1938, after nine months in the field, having concluded another field study of a significant and little known primate anthropoid type; this time the gibbons (*Hylobatedae*) of Siam.

The Asiatic Primate Expedition was organized during 1936 by Mr. Harold J. Coolidge, Jr., Dr. Adolph H. Schultz and the writer. The expedition was sponsored by Harvard University, particularly the Museum of Comparative Zoology and the Peabody Museum, by Columbia University through the Council for Research in the Social Sciences, by the Johns Hopkins University, especially the Medical School, and by the Carnegie Foundation of Washington. The main objectives of the expedition were three: (1) Dr. Schultz, Mr. Coolidge and Mr. Sherwood Washburn were interested in making an extensive collection of anatomical and taxonomic specimens for the study of intra-species structural variations. (2) The writer was interested in making a systematic field study of the naturalistic activities of the gibbon in its native habitat and a preliminary study of the orang outan. (3) Mr. Coolidge and his assistant, Mr. J. G. Griswold, were concerned in making a general collection of the birds and mammals of the region visited in Siam and Borneo. The expedition carried out its field work

in Siam, British North Borneo and Sumatra during the first nine months of 1937 and returned to the United States, having achieved its objectives to a degree beyond all expectations.

The major part of the collecting of primate specimens was done on Doi Internon and at Doi Chiengdao in northwestern Siam, not far from the Burmese border. Additional and important primate and general collecting was done in Borneo, where specimens of orang outans and proboscis monkeys were secured. However, the report of the Collecting Division is another story, and I shall deal in this article with some of the results of the Behavior Research Division, for which I was responsible.

In the plans for the expedition, I proposed to accomplish the following: (1) To make a systematic study of all observable modalities of the behavior, social relations and ecological relations of gibbons in the wild. (2) To make moving pictures and sound recordings of gibbon behavior. (3) To collect a small group of live gibbons to serve as the nucleus of a breeding colony which had been planned in connection with the School of Tropical Medicine at San Juan, Puerto Rico. (4) To conduct, in cooperation with Mr. Coolidge, a preliminary survey study of orang outans in the State of Atjeh, Sumatra, with the view of getting data which would make it possible to plan wisely and soundly a field study of this magnificent anthropoid. These objectives were achieved.

Behavior of Gibbons in the Wild

The scientific name for gibbons, *Hylobatedae*, signifies that they are forest travelers, and indeed they are! They are mainly arboreal, but may occasionally come to the ground for water or in order to cross short distances from one grove

REFLECTOR,

CENTER SECTION OF LARGE STRUCTURE SIX FEET IN DIAMETER, BEING USED TO PICK-UP GIBBON VOCALIZATIONS.

CAPTURED YOUNG MALE GIBBON OR GRAY COLOR PHASE OF *Hylobates* LAR, CHIENGDAO, SIAM.

YOUNG (H. LAR), IN TYPICAL SEATED POSITION.

of trees to another. During arboreal acrobatics, gibbons show two general types of locomotion, brachiating or swinging by the arms, and orthograde or walking on their inadequately developed hind legs. The swinging type comprises about 95 per cent. of the locomotor behavior in the jungle. The patterns of brachiation are well coordinated and effective, but the attempts at upright walking are awkward. When animals are brought into captivity, learning plays an important rôle in the adaptation of the ape to movement on flat surfaces.

The speed of locomotion is not as great as I had been led to believe from a review of the literature. The movements are fairly swift but sporadic. For a short period the apes may travel so rapidly that it is difficult to follow them on the run, as they make a kind of glide from tall trees to distant lower points. At such times they seem to touch limbs rather for guidance than support. However, these bursts of speed are of short duration and soon the animals slow down so that they may be followed easily, or indeed they may stop and rest. Nevertheless, the apes show remarkable visual-motor coordination which may reflect a very fast reaction time to visual stimuli and to judgments of distance and size.

The gibbon and the orang outan are the most arboreal of the anthropoid apes. Anthropologists postulate that the general posture and locomotor pattern as well as the other behavioral adaptations of gibbons may represent an evolutionary stage which is closely analogous to adaptations probably shown by the fossil ape *Dryopithecus*. Undoubtedly there have been deviating specializations, but the gibbon may be the nearest living approximation to the pre-human, pre-anthropoid common primate ancestor which lived in the Oligocene geological period. Thus, the study of gibbons takes on considerable theoretical significance.

Gibbons are primarily frugivorous in their food preferences. During my field work, more than forty fruit specimens were collected which made up in part the diet of gibbons in the wild. A large number of samples were also taken of stomach contents of freshly shot specimens. It was found that roughly 10 per cent. of the food in the stomach consisted of a mash composed of young leaves, flowers and buds, whereas the rest was composed of fruits and seeds. Field observations show, furthermore, that gibbons eat the eggs of birds, occasionally young nestlings and numerous insects and larvae.

Like other primates which have been studied in the wild, each group of gibbons has its specific and rather limited territorial range. The size of the territory possessed by a group relates to the size of the group, the location and concentration of preferred foods, available places for sleeping and resting or playing, pressure from adjacent groups and many other factors. Gibbons, being strongly conditioned to a limited territorial range, guard closely the area. Competition for territory, for foods and for homing areas is expressed by gibbons, as by howlers, more through aggressive and defensive vocalizations than by actual fighting. However, examinations of freshly shot specimens show cuts and torn ears which in all probability resulted from fights in which the long, keen canines were the effective weapons.

When comparison with reference to degrees of dominance and fighting are made within a large series of free-ranging primates, striking species differences are found, and furthermore, it seems indicated that arboreal primates show less tendency to pugnacity than the more terrestrial types. Another fact which is shown by field studies on competitiveness in primates is that the degree of competition is greatest within the species, a fact clearly stated by Darwin.

Field observers of wild animals have

YOUNG IMMATURE FEMALE (H. LAR) SHOWING WALKING POSTURE. ANIMAL IS SEARCHING FOR GRASSHOPPERS. CHIENGDAO, SIAM.

YOUNG MALE (H. LAR), ILLUSTRATING WALKING POSTURE.

perhaps exaggerated the competitive aspect of the animal's behavior to the neglect of accurate descriptions of socially coordinated behavior which functions importantly and advantageously for the species. In animals with highly developed bio-social behavior, there are many phases of this behavior which are highly coordinated, cooperative and mutually beneficial. I need only cite the facts that sexual activity is well coordinated and cooperative, maternal behavior involves numerous interlocking and reciprocally

ADULT FEMALE (H. LAR) IN THE WILD, SIAM. TYPICAL BRACHIATING POSTURE.

beneficial patterns of activity, while the play of the young, the establishment and maintenance of territory and group progression, all involve components of both cooperativeness and competitiveness.

A problem of central importance in primate field studies is that of ascertaining how a given sample population is organized. Especially is it important to learn what the characteristic group patterns are for the species being studied. The study of howling monkeys on Barro Colorado Island showed that in April, 1933, 489 ± 25 individuals were found in 28 groups which ranged in size from 5 to 35, with the modal group containing 18 animals. Within the group there was a larger number of adult females than adult males; in fact, there were approximately seven females to every three males. This *socionomic* or *tertiary* sex ratio is an important variant among species of free-ranging primates and one of the main axes of the group pattern. The tertiary sex ratio refers to the ratio between the number of adult males and adult females living in groups. In howlers, some of the males do not live within the groups, but live temporarily alone. By contrast, in spider monkeys, which have a somewhat comparable socionomic sex ratio, the excess males live in groups of males only.

What are the characteristic grouping patterns for gibbons? A total of 21 groups of gibbons were located, repeatedly checked and accurately described during more than three months of continuous work at Chiengdao, Siam. The groups contained a total of 93 individuals, and there were approximately an equal number of adult males and females. The groups ranged in size from two to seven with the modal group containing four animals. The characteristic gibbon group contains an adult male, an adult female and a succession of young up to a maximum of five. When a young one has been with the parent group until four or five succeeding young have been born, it has then matured sufficiently for it to separate from the parent grouping and become a part of the nucleus of a new group.

Group splitting or apoblastosis is that process of unequal division of natural societies of animals whereby the nucleus of a new group is formed from a parent group or groups. Groups split as a result of disequilibrium in the reciprocal, intragroup motives, of which the sexual motive is one of many, and because of effects

of extra-group incentives. Sometimes in gibbon groups, as was observed in Group 1, male and female siblings separate from the parent group and form a new society.

Much remains to be learned about reproductive behavior and physiology in gibbons. Few instances of copulation were observed. These were associated with elaborate patterns of secondary sexual activities. As far as could be ascertained in the field, it seems that in gibbons there is a comparatively low rate of birth and no discrete season of reproduction. The behavior of females while caring for their young constitutes one of the most interesting subjects for hundreds of hours of observational study.

Since vocalizations constitute an important part of the behavior of free-ranging gibbons, one objective of the Behavior Research Division was to make sound recordings of the calls of gibbons and attempt to learn their functions. For this purpose, especially designed sound-recording equipment of a semi-portable type was purchased and taken to Siam. Recordings were made by a Presto recorder on 12-inch acetate aluminum discs and the recorder was also equipped with a play-back attachment. A reflector made of a steel frame on papier-mâche coated with aluminum paint and six feet in diameter was used to supplement the pick-up powers of a special, directional microphone. Three hundred feet of cable made of a steel frame on papier-mâché mote from the turn table, transformer, battery set-up, and thus the possibilities of disturbing the animals were considerably reduced.

Twenty double-faced 12-inch discs were filled with recorded sounds, many of which, needless to say, were not of gibbons but of every piping, singing, denizen of the tropical forest, including everything from bees to great hornbills. The analysis of these sound records is now in progress, and detailed reports can not be given of the results. In general it seems that there are five types or series of sound patterns. Each series is distinct, is produced in a specific situation and produces in associated animals characteristic responses. Several times it was possible to stimulate the wild animals to call by playing back to them the recordings of their own calls which had just been made.

More than five thousand feet of 16 mm moving picture films were made of gibbons. The film, which is deposited in the library of Columbia University, shows wild gibbons in all aspects of locomotion, feeding, drinking, playing, and, in general, gives a good impression of the unusual behavior characteristics of this small but zoologically significant anthropoid ape.

I collected eight gibbons in Siam, brought them to Belawan, Sumatra, from which port I shipped them via the S. S. *City of Singapore* for New York. Not a single animal was lost during shipment! All but one of these apes have been sent to the School of Tropical Medicine in Puerto Rico, where they are to become the nucleus of a free-ranging breeding colony of gibbons. The colony will be located on the small island of Santiago, which lies just off the coast of Puerto Rico. The project is to be carried out under the auspices of the School of Tropical Medicine and the Department of Anatomy of the College of Physicians and Surgeons of Columbia University. In addition to the colony of gibbons, the project will involve a large breeding colony of macaques which will be used for medical research.

The Asiatic Primate Expedition has learned much about the anatomy, behavior and social relations of one of the most interesting primates below man. It is hoped that attention may have been called again to the smallest of the anthropoids, an ape which may become of the greatest importance in many branches of scientific research.

PARTICLES OF THE COSMIC RAYS

By Dr. KARL K. DARROW

PHYSICIST, BELL TELEPHONE LABORATORIES

WHEN a new member is admitted to a small and jealously restricted club supposedly already filled for all time, the event has a dramatic aspect. When a concept is formed in a nebulous way and rapidly gains precision with the passage of the years, the story is of philosophic interest. When physicists extend their knowledge into ranges of energy heretofore unsuspected, and find them inhabited by particles classifiable as electrons but in possession of powers ordinarily unknown, and also by particles which must be put in a class by themselves—when such things are available for telling, the tale has scientific value. When evidence comes in the form of pictures so striking as those which can here be shown, the science of lifeless matter has an esthetic splendor such as rarely embellishes it. All these features appear in the recent advances of the study of cosmic rays.

The small and exclusive club consists of the subatomic particles, long supposed to comprise only the negative electron and the proton and other positive atom-nuclei. Into it the positive electron had been forced in 1932, the neutron a few months earlier; a chair was being reserved for the negative proton, which as yet has not turned up to claim it; few if any expected the actual applicant. The concept now hardening into the definite form of this applicant is that of the "mesotron." This is a particle presumed to be equal in charge to the electron, but in mass a couple of hundreds of times as great. In so naming it I follow (C. D.) Anderson's recent proposal, though other titles such as "barytron" and "heavy electron" are already more or less firmly rooted in the literature. The quality which marks it out, when it appears with enormous energy among the cosmic rays, is an extreme and almost incredible power of penetration. This means that the so-called mesotrons are able to traverse decimeters, nay even meters of lead (or of dense matter generally). Like electrons, mesotrons may be of either sign of charge. As for the cosmic-ray particles still classified as electrons, *they* are marked out by their power of producing one of the most magnificent phenomena of nature, the "shower of cosmic rays" or "shower" for short. Shower-production by the supposed electrons, penetration by the supposed mesotrons, ionization along the course of either corpuscle through air: these are the three phenomena which will furnish most of the illustrations, much of the text of this article. The story of their incorporation into the structure of physical theory will furnish the remainder.

(But negative electrons and protons, not to speak of other atom-nuclei, have been identified through having their charge-to-mass ratios measured with the aid of electric and magnetic deflecting fields in elementary classical ways. Why then do I not cut this introduction short by giving the results of such a measurement upon the mesotron? The reason is that no such measurement has yet been made. Probably one will be made ere long. Should it give something near to the result expected, the delay will not have been regrettable; for the end of the delay will mark the beginning of the time, when the story to be related in these pages will be regarded as being "of historical interest" only—which is to say, that it will then be liable to be forgotten.)

FIG. 1. TRACK OF A COSMIC-RAY PARTICLE (PROBABLY AN ELECTRON) IN THE EXPANSION-CHAMBER, TIME HAVING BEEN ALLOWED FOR THE IONS TO DRIFT APART BEFORE THE EXPANSION. (CORSON AND BRODE, UNIVERSITY OF CALIFORNIA.)

So that the reader may see at once the three phenomena which are to bulk so largely in this story, I draw his attention at once to some of the pictures which decorate this article.[1] Nearly all of them were made (of course) with the aid of the cloud-chamber or expansion-chamber of C. T. R. Wilson, that device so precious in physics and precious in so many ways.[2]

At the beginning I place, as Fig. 1, a picture of the track of a cosmic-ray particle believed to be an electron. Any one who has ever studied the pictures of cloud-chamber tracks will at once be impressed by seeing how distinctly the droplets stand apart. This separation was achieved by letting half a second elapse from the instant when the electron shot through, to the instant when by expansion the gas of the chamber grew suddenly cool and the water-vapor suspended in the gas condensed itself as dewdrops on the ions. These ions, formed by the passage of the electron, had been diffusing through the gas during the half-second intervening, and the diffusion-process had served in the main to carry them apart (though there must also have been cases of ions approaching and possibly even combining with each other). The counting of these droplets is germane to the question as to whether the traversing particle was or was not an electron. This question, however, we leave till later, and turn to photographs in which the droplets of the tracks lie close together and are uncountable, because the expan-

[1] They decorate it with particular clarity, thanks to the kindness of Messrs. Anderson, Auger, Brode, Corson, Fowler, Fussell, Neddermeyer, Stevenson and Street in supplying me with prints of their splendid photographs.

[2] The expansion-chamber contains moist air (or some other gas saturated with water-vapor) and is bounded by several fixed transparent walls and one movable wall. When the movable wall is suddenly displaced outwards by a previously decided amount, the air expands and is sharply cooled by the expansion, and the water-vapor precipitates itself in droplets upon whatever ions may be present in the chamber.

sion took place before there had been time for much diffusion. Tracks so formed have the advantage of sharpness over what they lose in detail.

Fig. 2 presents the track of a particle which traversed a plate of lead as it shot across the chamber. In passing through the lead, it underwent no sensible deflection; no other particle sprang from the lead; and there is nothing in the aspect of the track which differs on the two sides of the metal. It would be more impressive yet to present a similar picture for a particle traversing ten or fifty centimeters of lead, but here the practical limitations on the size of a Wilson chamber defeat the physicist, or at any rate no one has overcome them yet. Ehrenfest has lately circumvented them by the laborious scheme of setting up *two* Wilson chambers, one above the other, with as much as 9 cm of lead or gold between them. However, the passage of single charged particles through thicknesses as great or even much greater is amply attested by the scheme of apparatus sketched in Fig. 3, even without the cloud-chamber there indicated by "Ch."

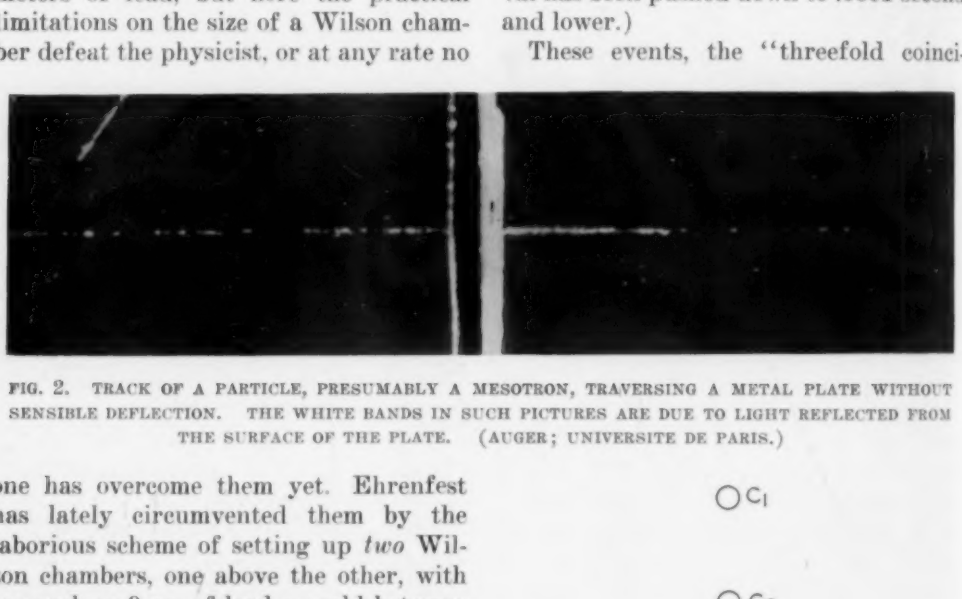

FIG. 2. TRACK OF A PARTICLE, PRESUMABLY A MESOTRON, TRAVERSING A METAL PLATE WITHOUT SENSIBLE DEFLECTION. THE WHITE BANDS IN SUCH PICTURES ARE DUE TO LIGHT REFLECTED FROM THE SURFACE OF THE PLATE. (AUGER; UNIVERSITE DE PARIS.)

In this sketch of Fig. 3, the objects C_1 and C_2 and C_3 are Geiger-Müller counters: that is to say, gas-filled discharge-tubes of a very special design, the two electrodes of each being an axial wire and a coaxial cylinder, and the electrode-size, voltage and gas-content being very carefully adjusted. These long large cylinders, usually called simply "counters" without the prefixed names, are familiar sights in almost every laboratory where cosmic rays are studied. If a charged flying corpuscle penetrates such a tube, a momentary discharge takes place in the gas. If such discharges spring up simultaneously in all the three tubes of such a system as Fig. 3 exhibits, the event is recorded by a mechanism. ("Simultaneously" is of course a word which requires detailed exegesis; it meant at first that in all tubes discharges began within 0.01 second of each other, but this interval has been pushed down to .0001 second and lower.)

These events, the "threefold coinci-

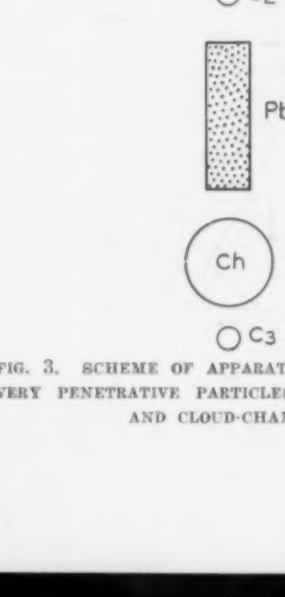

FIG. 3. SCHEME OF APPARATUS FOR OBSERVING VERY PENETRATIVE PARTICLES WITH COUNTERS AND CLOUD-CHAMBER.

dences," do actually occur. Of course, since in each of the tubes a discharge occurs now and then by itself, some of the coincidences must be the result of chance; but the probable number of these meaningless ones can easily be estimated from the frequency and the duration of the individual discharges, and in the best experiments they are a small minority. For the great majority, the simplest of explanations is to attribute each of them to a single vertically-flying particle cutting through all the counters in succession. Yet there are other thinkable causes, and confirmation of this simplest idea is needed. It was supplied when the cloud-chamber, "Ch" in the figure, was inserted. The chamber was compelled by mechanism to expand, always when and only when a threefold coincidence happened; and at the great majority of its expansions it showed a vertical track. Fig. 3 exhibits the arrangement of Street, Woodward and Stevenson at Harvard, who found the track of the traversing particle at 202 expansions out of 219. Auger and Ehrenfest at Paris had already set up *four* counters and a cloud-chamber and a block of lead in a vertical line, and found the track of the single traversing particle at fifty-five expansions out of sixty-nine. Another test is made by displacing one of the counters out of line with the others, whereupon it is found that the coincidences fall off in number sharply. And now to come to the point which most concerns us: there were 45 cm of lead between the counters in the experiment of Fig. 3, and 50 cm in the experiment by Auger and Ehrenfest, and no fewer than 101 cm in an early experiment of Rossi's with counters though without the chamber! Such is the power of penetration of some of the charged corpuscles of the cosmic rays.

The reader has now been introduced to charged particles which bore through quantities of lead, apparently without doing or suffering anything. Next he is to be introduced to particles which begin

FIG. 4. THREE SHOWERS, TWO EVOKED BY CHARGED PARTICLES AND ONE PRESUMABLY BY A PHOTON. (STREET AND STEVENSON, HARVARD UNIVERSITY.)

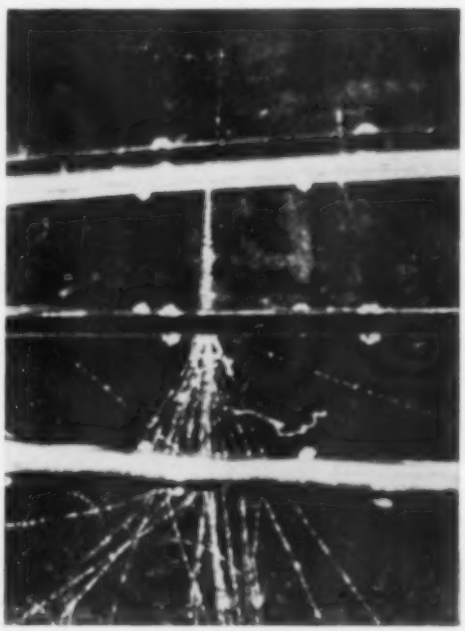

FIG. 5. SHOWER BEGUN BY A CHARGED PARTICLE IMPINGING ON A 6.3-MM LEAD PLATE, AND MULTIPLIED AS IT PASSES THROUGH A SECOND SUCH PLATE; IN THE THIRD PLATE, 0.7 MM THICK, ONLY DEFLECTIONS OCCUR. (FUSSELL, HARVARD UNIVERSITY.)

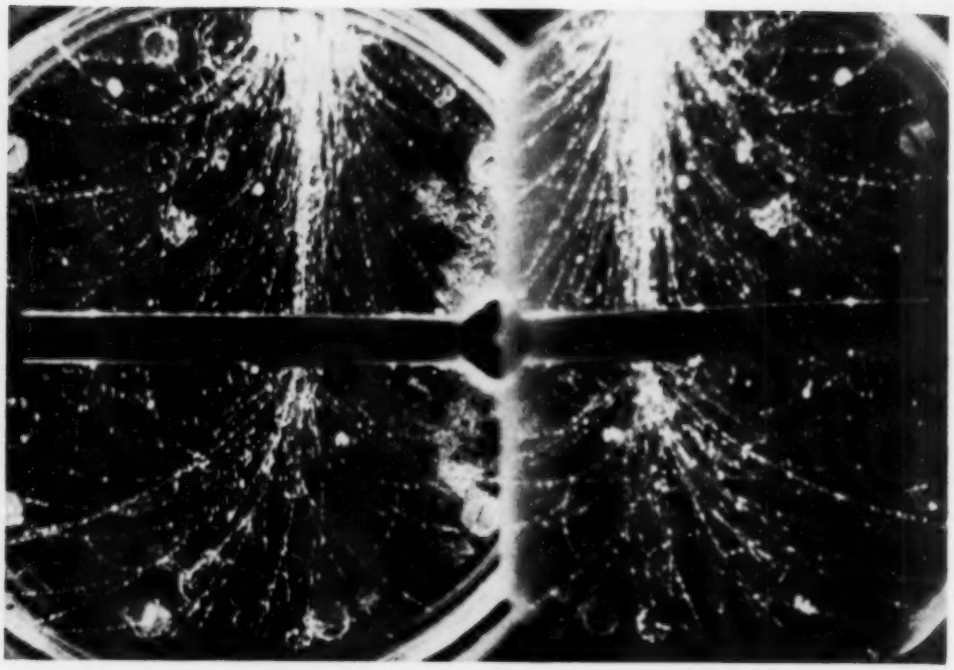

FIG. 6. SHOWER COMPRISING PHOTONS ATTESTED BY THE (CURLED) TRACKS OF SLOW ELECTRONS RELEASED IN THE GAS. (ANDERSON AND NEDDERMEYER, CALIFORNIA INSTITUTE OF TECHNOLOGY.)

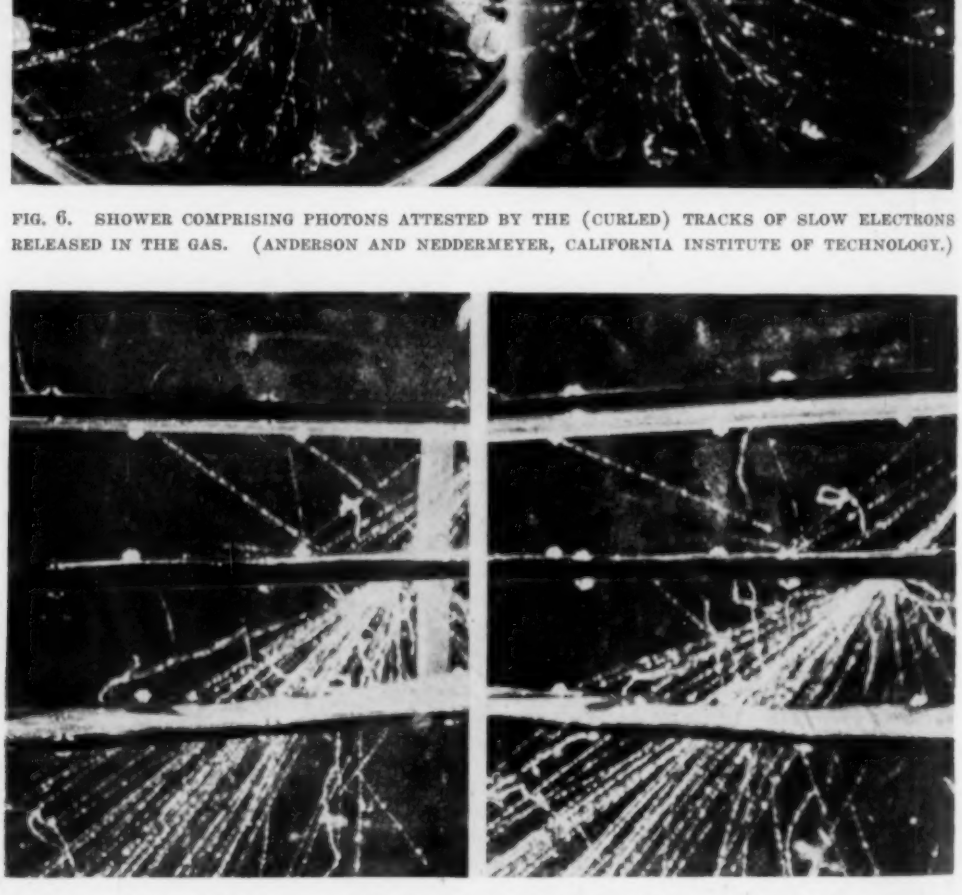

FIG. 7. ANOTHER EXAMPLE OF A SHOWER UNDERGOING MULTIPLICATION AS IT PASSES THROUGH METAL PLATES. (FUSSELL.)

to do something startling, when they have scarcely more than entered into a thin metal plate. This is vividly shown to him in Fig. 4, in which—after he can detach his eyes from the pretty sight beneath the transverse leaden plate—he will see that two of the "showers" beneath spring from the places where the metal was entered by two charged particles coming from above. These are accordingly called "shower-producing particles."

Figs. 5 and 6 and 7 show examples of showers even more gorgeous—regular cloudbursts, to continue with the metaphor (and indeed the term "burst" is often used as a synonym for "very large shower"). Of these, the special value of Fig. 6 is that the tracks that start in the gas itself bear witness to corpuscles of light—photons—included in the shower; for these are the tracks of electrons ejected by photons from atoms of the gas. (The agent which bends them into curlicues is, of course, a magnetic field applied to the whole of the Wilson chamber.) Showers, then, comprise photons as well as charged particles. The special value of Figs. 5 and 7 is that they show the progressive aggrandizement of showers as these pass onward through dense matter. This is called "the multiplication of showers." *Shower particles are themselves capable of being shower-producing particles.* One could not tell from these figures whether the multiplication is due to the charged particles or the photons, to either singly or to both. Here again the reader may consult Fig. 4, in order to notice that one of the three showers there depicted sprang from a place in the plate to which no charged particle came. This suggests that a photon may cause a shower, and that the multiplication of a shower already begun is due to the action of its charged particles and of its photons both.

Two classes of charged particles begin to take shape: the penetrating ones on the one hand, the shower particles and the shower-producing particles classified together on the other. To bring out another aspect of the distinction, I now turn to the data underlying Fig. 8.

These data are derived from cloud-chamber photographs such as Fig. 9 exemplifies. If the track of a charged particle is sensibly curved in such a magnetic field as it is possible to apply to a Wilson chamber, it may be possible to infer the momentum and the energy of the particle.[3] I digress to give the formulae, so as to make it clear just what can be deduced from what amount of knowledge. The elementary procedure consists in pointing out that the charged body describes a circle in the plane perpendicular to the magnetic field, and that consequently the force exerted on it by the field is to be equated to the product of its mass by its centrifugal acceleration. Putting ne for the charge (in electrostatic units) of the corpuscle, m for its mass, v for its speed and p for the magnitude of its mo-

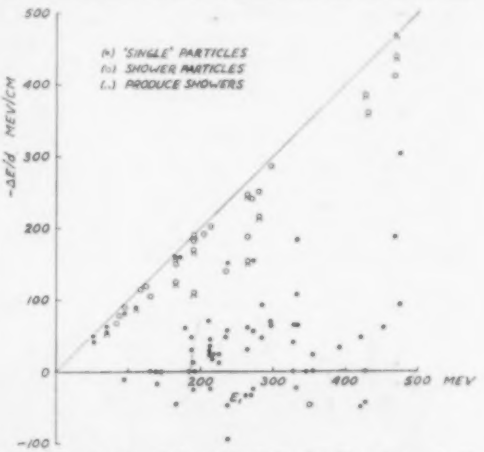

FIG. 8. ENERGY-LOSSES PER UNIT LENGTH OF PATH (IN MEV/CM) SUFFERED BY 94 COSMIC-RAY PARTICLES IN TRAVELING THROUGH PLATINUM. (ANDERSON AND NEDDERMEYER.)

[3] Curvatures of tracks being so very important in this field of research, it is necessary to examine with the greatest of care into all of the causes (apart from magnetic field) which may produce or affect them. Notable among these

mentum in the plane normal to the field, ρ for the radius of the circle and H for the field-strength, and writing down the two members of the equation, one finds:

$$Hnev/c = mv^2/\rho, \quad (1)$$

$$p = (ne/c)H\rho. \quad (2)$$

These equations remain valid when (as usually is the case with cosmic-ray electrons) the speed is so great that relativistic mechanics must be used instead of ordinary. At such high speeds equation (2) retains its aspect. Equation (1) may also be left unaltered, but one must be sure to remember that m is a certain function of v:

$$m = m_0\sqrt{1 - v^2/c^2}, \quad (3)$$

m_0 being known as the "rest-mass" of the body.

Equation (2) does not involve the mass at all. In the usual loose phrasing, $H\rho$ *gives the momentum of the particle provided that its charge is known.* The like can not be said for the energy, which is given by $H\rho$ only if both the charge and the rest-mass are known. For particles of the cosmic rays it is best to disregard the ordinary expression for kinetic energy ($\frac{1}{2}mv^2$) and adopt for good the relativistic expression mc^2, to wit, $m_0c^2/\sqrt{1 - v^2/c^2}$. Of this the portion m_0c^2 is not kinetic energy: it is the "rest-energy" associated with the "rest-mass" m_0, inseparable from the particle so long as this exists; it amounts to about half-a-million electron-volts or 0.5 Mev for the

are currents in the gas, which are especially obnoxious if there is a metal plate in the chamber. Indeed it seems strange that the currents should not be more hampering than they are, considering the expansions which occur. Sometimes people observe that in the absence of magnetic field, there is a slight curvature of the tracks; then in the presence of magnetic field, they deduct this amount from the curvatures observed. The papers of Anderson and Blackett abound in information on these delicate questions.

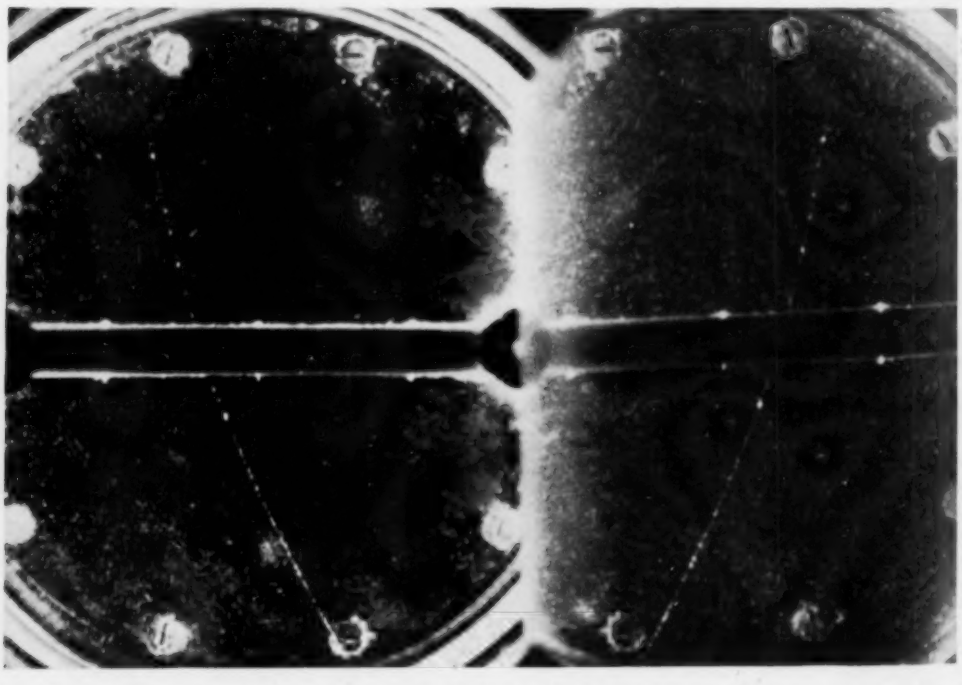

FIG. 9. TRACK EXHIBITING MEASURABLE AND UNEQUAL CURVATURES ON THE TWO SIDES OF A METAL PLATE, THUS INDICATING CHANGES OF ENERGY AND MOMENTUM SUFFERED IN THE TRAVERSAL. (ANDERSON.)

electron, to about 1,000 Mev for the proton. The remainder may be called kinetic energy. For nearly all the electrons and most of the other cosmic-ray particles, this remainder is by far the greater part. The dependence of the kinetic energy upon $H\rho$ is exhibited, for electrons and for protons, by Fig. 13. One sees that for different masses a given $H\rho$-value leads to different energy-values, but also that the error due to an incorrect estimate of rest-mass becomes proportionately smaller as the $H\rho$-value increases. Yet the possibility of the error *is* always there, if the mass of the particle is not certainly known; and it affects many published "energy-values" based on the presumption—often admitted in the context to be more than doubtful—that the particles to which they refer are electrons. The danger might be mitigated by describing these as "quasi-energy-values" expressed in "quasi-Mev."—For actual electrons with momenta as great as those figuring in the cosmic rays, the energy-value in electron-volts is practically equal to 300 times the $H\rho$-value expressed in gauss-centimeters.

Many a cosmic-ray particle suffers no deflection that can be detected in its entire course across a Wilson chamber (diameter, 15 cm or even more) in a magnetic field as strong as can be applied over so great a volume (field-strength, 20,000 gauss or thereabouts). One might well be tempted to think such a particle chargeless, for if this were the case, the field would have no grasp at all upon it; but if it were chargeless it could not ionize the molecules of the gas and therefore could not form the chain of ions on which the droplets are founded. In some of the finest of the experiments (those in Pasadena and those in Paris) a detectable curvature of the track would be shown if this were made by an electron of energy so enormous as $2 \cdot 10^{10}$ electron-volts (20,000 Mev!). The uncurved tracks accordingly speak of electrons of energies greater than 20,000 Mev, if these particles are electrons; and the inference is not much less drastic, if they are more massive than an electron.

We, however, are more interested, for the present, in the tracks which are sensibly curved; and most of all, in the tracks which are intersected by a metal plate and which show a curvature on one side of the plate and a larger curvature on the other (Fig. 9). From the two ρ-values one can deduce the momentum-loss Δp and the energy-loss ΔE suffered by the particle in passing through the plate. (Yet I emphasize again that Δp is computable only if the charge is correctly guessed, and ΔE only if the rest-mass is correctly guessed in addition to the charge.) With this ambition Anderson inserted such plates for the first time into a Wilson chamber, in 1931. The idea had a wonderful and unforeseen result, some years ago recounted in these pages. Notice that above I spoke of the momentum-*loss* and the energy-*loss* suffered by a particle in going through a plate. In so doing I was making the assumption that it is a loss and not a gain which happens. If this highly plausible assumption is correct, then the sense in which the particle is traveling its path is knowable; it is from the side of the plate on which the curvature is less, to the side on which the curvature is greater. If the sense of the motion is knowable, so also the sign of the charge of the particle is knowable, being positive or negative according as the track is bent with its concavity toward the left or toward the right of an observer looking into the chamber from the north-seeking pole of his magnet. Without the plate, neither sense nor sign would be knowable except in the rarest of cases.[4] Anderson in August, 1932,

[4] One might be misled by the adjective "cosmic" into believing that all cosmic-ray particles come from above, their sense of motion making an angle of less than 90° with the downward-pointing vertical. Many, however, including Anderson's first positive electron, have been

found on one of his photographs the track of a particle which by this criterion was positive, and which by the density of droplets along its track (we take up this topic later) he identified as an electron. He thus became the discoverer of the positive electron.

Concentrating on the measuring of ΔE after the excitement of the positive electron had subsided, Anderson presently found that its values are very fluctuating. Thus in 1934 he published the details of nine traversals, made by particles assumed to be electrons, through thicknesses of lead from 7 to 15 mm. (Even with a single metal plate the effective thickness varies, since corpuscles traverse the plate with varying degrees of obliqueness.) These were by no means identical in initial energy, this ranging from 38 to 240 Mev; nevertheless, one might have expected the energy-loss per unit length of path in lead to be about the same for all, and yet the nine values thereof were scattered all the way from 18 to 120 Mev/cm! Such fluctuations suggest that the energy is lost in great amounts at a few events, and not in driblets at many. They did not deter Anderson and Neddermeyer from making such measurements on hundreds of later particles, classifying the particles into groups according to their energy-values, and averaging the energy-losses within each group. What then was found has a bearing upon the problem; but we pass over it for the time being, and consider in Fig. 8 the record of ninety-four particles which, during a later experiment, passed through a plate of platinum one centimeter thick.[5]

Plotted horizontally are the energy-values of the particles while above the plate, vertically the energy-changes divided by the lengths of path in the platinum. The axis of abscissæ is the locus of energy-losses imperceptibly small; the line slanting at 45° is the locus of energy-losses which are total, the particles shown on this line having been stopped by the plate. The fact that some of the representative points lie below the horizontal axis means only that for every particle the observers subtracted its energy below the plate from its energy above, irrespective of its direction of motion. Suppose that these subjacent points correspond to upward-going corpuscles, and transfer them across the horizontal axis. Then, the sprinkling of points extends all the way from axis to slanting line; and this is the sign of fluctuations such as Anderson from the start had observed. Notice, however, that the representative points are of four aspects: solid dots and hollow circles, with or without downward-pointing barbs. The dots refer to tracks which were seen in the chamber singly; the circles to particles which "entered the chamber accompanied by other particles." The lonely particles are prevailingly able to pass through matter without suffering energy-losses nearly so great as those which the others incur! Thus by itself and without any theory, Fig. 8 establishes a distinction between the singly-appearing corpuscles on the one hand and those which appear in company on the other. Moreover, the barbs are often attached to the hollow circles, bearing out the inference from Figs. 5 and 7 that shower particles are likely to be shower-producing particles; but rarely are they attached to solid dots, never to those which lie far off from the slanting line.

(This seems the best place for mention of the similar work now being done in England by Blackett and (J. G.) Wilson, in France by Ehrenfest.[6] The Englishmen have set plates of gold, lead, copper and aluminum, of various thicknesses from 3.3 mm to 2 cm, into the middle of an expansion-chamber in Anderson's fashion; Ehrenfest, using a pair of cloud-

found by this criterion to be moving upward (*i.e.*, at more than 90° to the downward-pointing vertical). The showers of Figs. 6 and 7 show that this is not a forced interpretation.

[5] I am indebted to Dr. Anderson for a plate exhibiting data thus far unpublished.

[6] I regret to mention the sudden untimely death of this brilliant and amiable youth.

chambers one over the other, was able to put between them a block of gold no less than 9 cm thick! Their way of reducing their data for plotting is not the same as that employed at Pasadena, and their diagrams therefore look very different[7] from Fig. 8. Their energy-range runs much further upward, as far as 5,000 Mev, and the great majority of the particles which they plot lie beyond the limit of Fig. 8. Many of Ehrenfest's particles got through the great thickness of gold without losing anywhere nearly the whole of their energy, and are therefore to be classed as much more penetrating than electrons should be. So did nearly all the particles of energy greater than 250 Mev observed in England, but there were a few of these which lost most of their energy in 0.33 cm of lead, and of these few about half seemed to belong to showers. At energy-values below 200 Mev Blackett finds almost no penetrating particles, a singular contrast with the Pasadena observations; he suspects that the penetrating particles become ordinary electrons when they are slowed down into this energy-range. I mention also the measurements made on some twenty penetrating corpuscles by Leprince-Ringuet and Crussard, leading to the exceptional conclusion that positives suffer smaller energy-losses than negatives.)

But granting that there are two sorts of particle with a right to different names: has either a right to the name "electron"? To settle this question, and for several other reasons, it is time to call upon theory.

It is now some thirty years since there entered into physics a German word, *Bremsstrahlung*, which can be translated literally into English as "braking radiation," and would no doubt be so translated if "braking" did not sound like another English word of entirely different meaning. This is chiefly observed emerging from x-ray tubes, being emitted from their metallic targets when these are struck by the stream of bombarding electrons. It consists of photons or corpuscles of light, each containing at least a part of the kinetic energy of one of the incident electrons. The distribution-in-energy of the photon makes it clear that the electrons frequently lose large fractions of their initial energy *en bloc*, throwing it off in individual parcels which are these photons (indeed it sometimes happens that the entire kinetic energy of an incident electron is shed in the form of a single corpuscle of light). This radiation forms the so-called "continuous x-ray spectrum" or "x-ray continuum" emerging from targets of x-ray tubes. With the spectrum-lines which are sometimes seen superposed on this continuum we have nothing here to do.

By the classical theory of thirty years ago this continuous spectrum is attributed to the slowing-down of the electrons as they penetrate into the metal, whence the name *Bremsstrahlung*. By the quantal theory of to-day it is still ascribed to the slowing-down, which must now be conceived as taking place in instantaneous jerks, occurring probably in the close vicinity of atom nuclei. At each of the jerks, the electron-speed is suddenly reduced and the kinetic energy goes forth in the form of light. The later theory in its quantitative form gives a competent account of the continuous x-ray spectrum as it springs from the tubes of the laboratory, with their bombarding electron-

[7] For the benefit of those who may consult the original papers, I give the difference. Let E_1 and E_2 stand for the (quasi) energy-values of a particle before and after passing through a thickness d of metal; ΔE for $(E_1 - E_2)$; x for $\frac{1}{2}(E_1 + E_2)$. What is plotted by Anderson and Neddermeyer (Fig. 8) is $\Delta E/d$ as ordinate and E_1 as abscissa. Blackett (in all his papers but the earliest), Wilson and Ehrenfest begin by subtracting from ΔE a quantity sd which is supposed to be the amount of energy spent by the particle in detaching electrons from atoms while traversing the metal (Blackett assigns the value 15 Mev/cm to s in lead, Ehrenfest takes 28 for gold); they then plot $(\Delta E - sd)/xd$ as ordinate and x as abscissa. Their ordinate (denoted by them as R) is then more nearly ready for comparison with theory.

streams energized by voltages of a few tens or hundreds of thousands. For a long time nobody seemingly troubled to extend it to voltages of the order of thousands of millions; a futile extension indeed this would have been, so far as x-ray tubes are concerned. When finally the extension was made by people interested in the cosmic rays, it turned out that according to the quantal theory the liability of electrons to these "radiative energy-losses" goes up so greatly with increasing speed that electrons of even the cosmic-ray energies should not be able to bore their way through as much as five centimeters of lead!

After the meaning of this inference sank in, there ensued a period lasting for months (in 1935 and 1936) in which several eminent theorists were willing to concede that nature must have set a limit to the scope of quantal theory. It was beginning to be believed that somewhere between the energy-range attainable in the laboratory and the energy-range manifest in the cosmic rays, there is a critical energy-value beyond which the electron escapes from the sway of the quantal laws, and is exempted from losing its energy by the process of *Bremsstrahlung*. This belief was an artifice for permitting the penetrative particles of the cosmic rays to be called by the name of electron. It might have remained a credible artifice, if the penetrative particles had been the only ones—if, that is to say, there had never been any evidence for the existence of particles among the cosmic rays having the properties required of electrons by the quantal theory. Such a situation may have seemed to exist at the time when the belief was dominant. It exists no longer, as the description of Fig. 8 has just suggested; but before considering further the data, I must introduce something more of what the theory has to say.

Since 1934 it has been known that a photon of energy greater than about one million electron-volts is capable, when in the vicinity of an atom-nucleus, of converting itself into a pair of electrons of opposite sign. About one million electron-volts—1.02 Mev, to be somewhat more precise—becomes "rest-energy" of the twin electrons, being incorporated with their rest-masses; the remainder ($h\nu - 1.02$, if by $h\nu$ we denote the photon-energy in Mev) becomes kinetic energy of the electrons. The process may be produced at command and exhibited to the eye, by projecting the photons known as gamma-rays against metal targets contained in expansion-chambers. The gamma-rays originally used for this purpose proceeded from natural radioactive substances; mostly they were those emitted by a certain substance (thorium *C″*) with a photon-energy of 2.62 Mev. Nowadays gamma-rays of energy several times as great can be produced by effecting certain transmutations, in the course of which (or afterward) they emerge from the new-born nuclei. Fig. 10 shows an admirable example of an electron-pair formed out of such a photon. Moreover, the converse process is well known: positive electrons falling against a plate of dense matter bring about the emission of photons of energy 0.51 Mev, and these are just what are to be expected if the positive electrons (after being slowed down) unite with some of the innumerable negative electrons already in the plate and produce, at every such union, a pair of equal photons.[8] Much too abundant to be here described is the evidence for the ability of electron-pairs to pass into light and light to pass into electron-pairs, making it permissible to imagine a

[8] Evidently this is not quite the converse of the process previously described, which if reversed would consist in the merger of a positive and a negative electron with the formation of a single photon bearing away all their energy. Some evidence exists for the occurrence of this process. There is no sign of the fourth conceivable process (the meeting and merger of two photons to form two electrons) which must obviously be very rare in practice owing to the feeble concentration of photons in actual beams of gamma-rays. Nevertheless, this last is the process first predicted by the theorist Dirac.

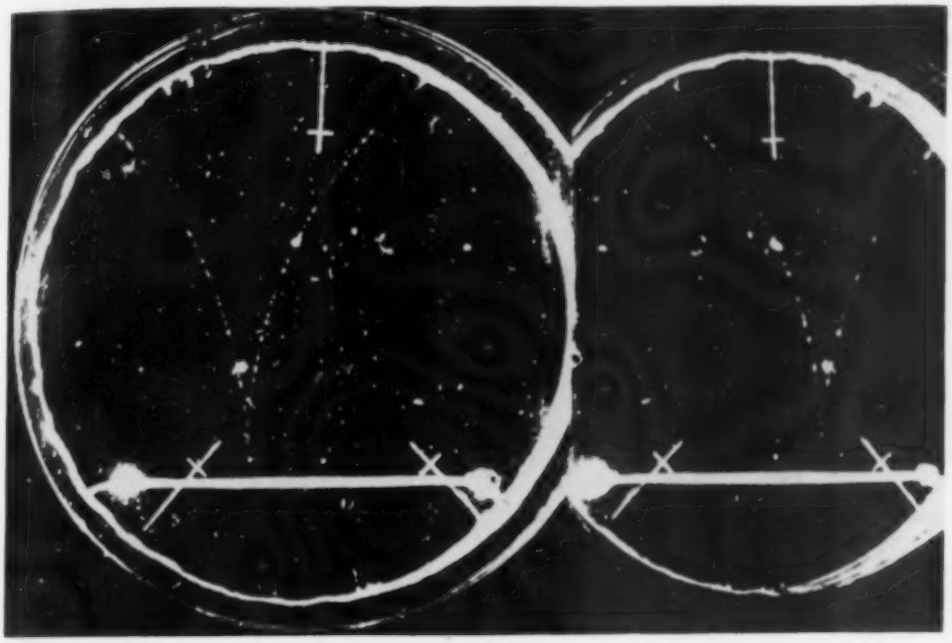

FIG. 10. AN ELECTRON-PAIR BORN FROM A PHOTON. (W. A. FOWLER, CALIFORNIA INSTITUTE OF TECHNOLOGY.)

continual alternation of energy between these two so sharply contrasted forms.

Formation of the photons of *Bremsstrahlung* by electrons of enormous energy and formation of electron-pairs out of such photons: these reciprocal processes engaged the attention of several theorists (Bethe, Heitler, Sauter, Weiszaecker, Oppenheimer) in the years 1933 and 1934. The problem was to evaluate by quantal theory the chance that electron or photon would spend its energy in producing photon of electron-pair, while traversing given thickness of given element. Approximations had to be made in the calculation, as nearly always in quantal problems; but they are supposed not to affect the rightness of the main result. To quote Oppenheimer's description of this result: "a beam of high-energy electrons should have a good part of its energy converted into photons in a centimeter of lead; in an equal distance these photons will be largely reconverted into pairs."

Such was the result from which, in 1935, it was inferred that quantal theory must be wrong because it was predicting something which could not be found in nature; and from which, in 1936 and thereafter, it was concluded that quantal theory not only was correct but had made a splendid triumph, in explaining the phenomena of showers! It is not altogether clear why the later conclusion was not drawn at the start; perhaps the reason is that as lately as the summer of 1936 fine photographs of showers were still rather rare, while such pictures as Figs. 5 and 7 with their examples of self-augmenting showers had not as yet been made. On the other hand, it would be premature to say and misleading to imply that the process which the theory describes is in exact and quantitative accord with the observations on showers. There are at any rate good grounds for hoping that as the mathematics of the theory is more fully worked out and the art of the experiments refined, the agreement will grow better and better. The most that seems safe to say is, that now we have a

general scheme for the interpretation of showers of a certain type, and a very hopeful prospect that this general scheme will be converted into a detailed and quantitative explanation as the mathematics of the theory on the one hand, the aptness and precision of the observations on the other hand are gradually improved.

By inserting the words "of a certain type" in the foregoing sentence, I leave open the possibility that showers may be classified into more than one type, and all these but one be ascribed to other processes. This is no mere possibility but already almost a certainty. Certain showers which include "heavy tracks" due to protons or still more massive particles are ascribed to nuclear explosions provoked by cosmic rays. If a shower fails to undergo the "multiplication" illustrated in Figs. 5 and 7, it is taken as belonging to this other type. Exception made for such cases, it is strongly plausible to say that shower particles and shower-producing particles are electrons; that accordingly high-energy electrons exist among the cosmic rays, behaving as the quantal theory says that they should; and that consequently the other particles, setting themselves apart from electrons by their penetrative power and their failure to make showers, are of another sort.

Ability to penetrate matter, inability[9] to make showers: these are the complementary aspects of the property which distinguishes this other type of particle, the mesotron. If one wishes to contrive a particle having this property and differing otherwise as little as possible from the electron, how must it be done? The electron has the qualities of charge and mass; also those of spin and magnetic moment, but these are considered (perhaps wrongly) to be little or not at all concerned with shower-production. If we imagine the mass to be increased while the charge remains the same, the liability to *Bremsstrahlung* will diminish; for *Bremsstrahlung* occurs when sudden sharp deflections or decelerations occur, and these are less sharp and sudden the more massive the particle is. Now *Bremsstrahlung* is the prelude to the entire manifold process of the forming of a shower, and hence a mere increase in the mass of the hypothetical particle leads in the desired direction. The theory indicates that a particle with the electronic charge and a few dozen times the electronic mass will be penetrating enough. We do not need, however, to be contented with such vague intimations, for there is yet another phenomenon in respect of which the mesotron differs from the electron, and from this the mass can be deduced more sharply.

So far, we have been considering the passages of particles through solids. There, the paths are concealed, the adventures of the particles can only be inferred—from the difference between energy before and energy after traversal, or from the photons and the secondary electrons which are driven out of the solid. Now we are to consider the passages of charged particles through the gas of the Wilson chamber, which, unlike the scriptural way of the eagle through the air, are preserved for our inspection by the droplets. Fig. 1 has shown to us a track in which the number of droplets in unit length of path can rather readily be counted. What does this number signify? And is it truly an indication of the mass of the traveling particle, as I hinted on an early page?

The latter question might perhaps be sufficiently answered without reference to the former; but for completeness, and for the sake of its own interest, the former ought to be treated more fully than it was in that brief earlier mention. In the voyage recorded in Fig. 1, nothing so drastic happened to the traversing particle as would have been the losing of a large part of its energy in the form of a photon of *Bremsstrahlung*. It lost its

[9] It is better to say "relative inability" since occasional showers are attributed to mesotrons, which perhaps operate by making a violent impact on an electron and so giving it the energy needful for starting the process.

energy in driblets, spent in detaching electrons from molecules and giving them a small extra bonus of kinetic energy with which to go wandering around in the gas. They had not speed enough to wander far, even in the half-a-second afforded them before the condensation. Probably they had already adhered to molecules before the condensing water immobilized them. One speaks of the droplets as being condensed partly on negative, partly on positive ions; the last-named are the molecules from which the electrons were reft. (If, during the half-a-second, an electric field of suitable strength is applied, the ions of the two signs drift in opposite ways, and when the water-vapor comes down there are seen two parallel trails of droplets with an empty space between.)

The simplest idea is that the traversing particle tears off one electron from each of many molecules through or near which it passes, and that half of the droplets are formed on these electrons and the other half upon the molecules bereft. This is too simple to be true. It is likely that sometimes the particle removes two electrons or more from a single molecule, so that there well may be more negative ions than positive. Much more serious is the certain fact that often when an electron is thus released by the direct action of the traversing particle, it shoots away with speed and energy enough to enable it to release one or several more from neighboring molecules. Now and then one comes on a cloud-chamber photograph in which there appears a track with branches (Fig. 11); each of these is the trail of an electron which has received a truly abnormal and extraordinary amount of energy. Much commoner, in fact universal, is the "beaded" appearance of such trails as appear in most of the pictures of this article: it is presumed that each of the beads is an unresolved cluster of droplets formed on a cluster of ions, all but one pair of them made in the indicated way. Occasionally one sees a picture in which the interval allowed for diffusion has been so happily chosen that the droplets in the clusters are far enough apart for counting, and yet consecutive clusters do not overlap. In making Fig. 1 the interval allowed was a little too long, and yet perhaps it is possible to think that the ions are denser in some parts of the trail than in others, as though they had been formed in clusters which have broadened almost but not quite to the point of losing their identity.

It is therefore necessary to distinguish, in mind if not in fact, between the "primary ionization" consisting of the electrons and the molecules torn apart from each other by the direct immediate action of the traversing particle,[10] and the "entire ionization" (sometimes called "probable ionization") consisting of these together with all the ions formed by the directly ejected electrons. Under ideal conditions it is presumed that the measure of the former would be the total number of droplet-clusters,[11] the mea-

[10] Unluckily called "secondary ionization" by some of the German theorists.

[11] Best to observe the droplet clusters as individual entities, one would wish the expansion to occur before the ions have any time at all to diffuse. To attain this, Williams and Pickup caused the chamber to expand at moments taken at random, and trusted to luck for the appearance of cosmic-ray tracks formed at just the right instants. Luck served them with no fewer than four tracks betokening particles of a distinctive mass.

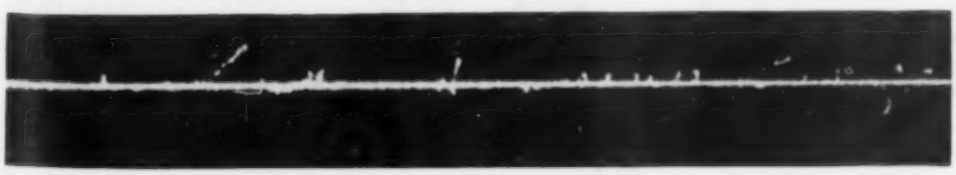

FIG. 11. TRACK OF A CHARGED PARTICLE BRISTLING WITH SHORT BRANCHING TRACKS, MADE BY ELECTRONS EJECTED FROM ATOMS WITH ENERGY SUFFICIENT TO IONIZE. (AUGER.)

sure of the latter would be the total number of droplets, in unit length of path. Not many physicists have tried to evaluate both of these numbers. Of those who have, the data have been scanty, but the consensus of opinion is that the latter is about or not quite twice as great as the former. It is, however, likely that the value of the ratio of the two is not important when one wants only to distinguish between electron and mesotron, as we shall presently see.

The problem of the primary ionization is one of the major tasks of theoretical physics. Classical and quantal theorists alike have spent great labor on the question: given a charged particle of specified charge and mass and speed traversing air (or any other gas), how many electrons will it set free from the molecules in unit length of path? At this point I will give only one of the results—or rather, something which is not a result at all, but a part of the assumptions. It is assumed that as the traversing charged particle flies along through or close to a molecule, it operates upon the electrons thereof by virtue of the ordinary electric forces between its charge and the charges of the electrons. It follows, then, that *whatever expression finally may be derived for the primary ionization must depend only upon the charge and the speed of the traversing particle, and not upon its mass.* (Mass and momentum of the particle must indeed be great enough to hold it on a sensibly straight course as it plows onward through the gas, despite its losses of energy as it detaches electrons; but this condition is always realized, with the corpuscles of the cosmic rays.)

I seem to have said that the primary ionization gives no power of distinguishing between an electron on the one hand, a particle of equal charge and different mass on the other. However, it *does* confer on us this power, for the reason that the curvature of a particle-track in a known magnetic field is a measure not of particle-speed but of particle-momentum

FIG. 12. TRACK OF A MESOTRON SLOWED DOWN BY AN OBSTACLE IN A WILSON CHAMBER AND FINALLY BROUGHT TO A STOP IN THE GAS OF THE CHAMBER ITSELF. (NEDDERMEYER AND ANDERSON.)

(equation 2). If by luck an experimenter should happen upon two tracks having the same curvature but made by particles having masses[12] standing to one another in the ratio (say) 100:1, the speeds would stand to one another in the ratio 1:100, and this might well entail a perceptible difference in the primary ionization. It would come to the same thing, if some one should take the data for a large number of tracks, and plot primary ionization as function of curvature: if there are really two kinds of particle differing in mass, there should be two sets of points lying along two curves, and from the ordinates of these curves at any abscissa the ratio of the masses would be derivable.

Perhaps the last sentence suggests that some one already has made this correlation, and has found that the points for all the single or penetrating particles lie upon one curve, and all the points for shower-particles and shower-producing particles lie on another. This has not been done. The reason is that many of the penetrating particles exhibit no perceptible curvature of track at all, and most of the others a very small curvature. The former are moving so fast that their momentum can not even be estimated, except as being beyond a certain critical value. As for the latter, the speeds of even these are so great as to approach the speed of light; for a given momentum-value the speed varies only a little with the mass, and the primary ionization varies too little to serve as an index of mass. To make a profitable correlation, one must use only the particles of which the tracks are notably curved. Nearly all these are shower-particles, which already are presumed to be electrons. To find a penetrating particle with a highly-curved track, one must find it when it is near to the end of its course and its energy well-nigh gone. Such is the principle which directed some of the recent successful searches for particles proclaiming themselves by their ionization to be more massive than electrons.

Before looking at the track of one of these particles, we ought to notice a couple of questions concerning ionization. One of them is: is the distinction between primary and entire ionization—or rather, our lack of perfect ability to make it in practice—likely to lead to trouble? Many observers are far from clear in reporting whether what they observe is more like the one or more like the other; but it seems probable that the second like the first is dependent only upon the speed and the charge of the traversing particle, not on the mass thereof; and this diminishes the dangers from confusing the two. The question is implicated with the second: to what extent do experiment and theory aid us in identifying the shower-particles with the electrons? As to experiment, there exist the records of a few studies made by the Wilson chamber upon particles acknowledged to be electrons, of energy-values ranging from about 2 Mev downward to some 25,000 electron-volts. In respect of the trend with energy, they agree fairly well with the assertions of the quantal theory; but when one inquires whether the absolute value for the number of clusters of ions in unit length agrees with the absolute value of the quantal expression for the primary ionization at any particular energy, one is confronted with the fact that the quantal expression contains a multiplying factor which depends on intimate details of the structure of the molecule, and is not exactly known. The quantal theory, however, predicts a minimum in the curve of primary ionization *vs.* energy, at an energy of about 2 Mev. Such a minimum (Fig. 13) was actually found by Corson and Brode in their study of some fifty particles of the cosmic rays, and probably is to be ranked as evidence for the electronic nature of these particles quite as forcible as would be an absolute agreement between the observed ioniza-

[12] Allowance being made for the relativistic dependence of mass on speed.

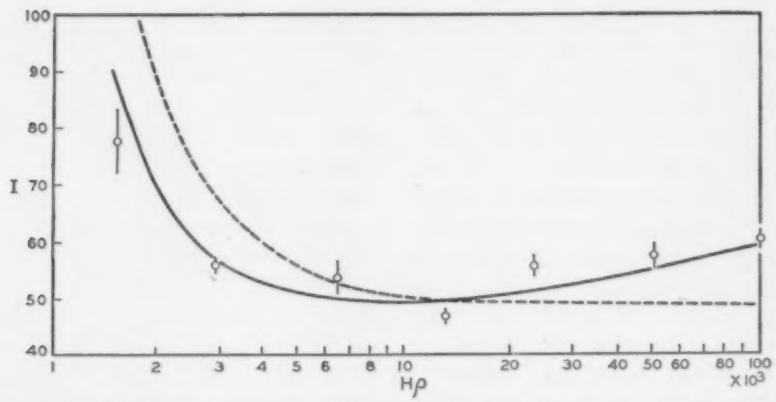

FIG. 13. IONIZATION-DENSITY (ENTIRE) ALONG THE TRACKS OF COSMIC-RAY PARTICLES, PLOTTED AS FUNCTION OF $H\rho$. THE CONTINUOUS CURVE IS THAT OF A THEORETICAL FUNCTION CONTAINING A MULTIPLYING FACTOR WHICH HAS BEEN ADJUSTED TO GET THE BEST FIT TO THE DATA. (CORSON AND BRODE.)

tion and the predictions of a reliable theory.

Street and Stevenson, with a row of counters and an interposed cloud-chamber such as appeared in Fig. 3, adjusted their counters in such a way that the chamber expanded only when the counters above the chamber had simultaneous discharges and the counter below did *not*. A thousand photographs yielded to them the track of one particle having a notable curvature and displaying an ionization six times as great as that attributable to an electron; they inferred a "mass 130," *i.e.*, a rest-mass one hundred and thirty times as great as that of an electron. Neddermeyer and Anderson transposed the bottommost counter into the very center of the cloud-chamber itself, and there it appears in Fig. 12, neatly intersected by the course of a particle which above it made a track lightly curved and thinly studded with droplets, and beneath it made a track sharply curved and densely congested. Comparing ionization with curvature along the track above and the track below, they found 240 to be a satisfactory ratio of the mass of the traversing particle to the electron-mass. Williams and Pickup, to whose technique I have already alluded (footnote 9), observed four tracks of which three were compatible with a rest-mass of about 200, the remaining one requiring a mass-value between 430 and 800. A few more such tracks have appeared in the literature, but instead of describing them I turn for the climax to another and an exacter way in which Fig. 12 furnishes the desired value of mass.

In Fig. 12, the track beneath the counter comes to a sudden end. One could take a sheet of coordinate-paper, and plot along the horizontal axis the curvature of the path as it emerges from the coun-

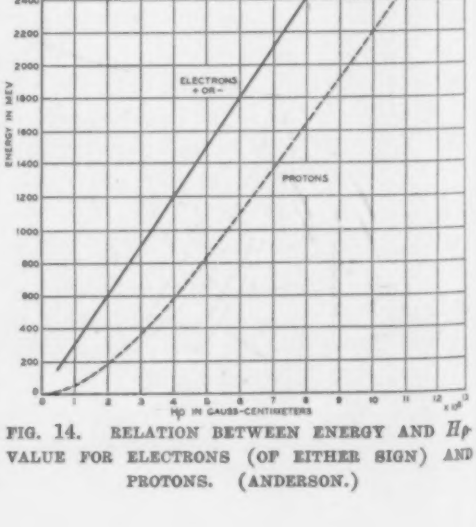

FIG. 14. RELATION BETWEEN ENERGY AND $H\rho$ VALUE FOR ELECTRONS (OF EITHER SIGN) AND PROTONS. (ANDERSON.)

ter, and along the vertical axis the length of the path from that point of emergence onward to its end. This would give a single point of what is known as a "range-*vs.*-curvature" relation or a "range-*vs.*-momentum" relation. A second point can be found by measuring the thickness of the glass counter-wall twice traversed by the particle, converting it into an equivalent thickness of gas, adding this to the length of the path beneath the counter, and correlating the sum with the curvature of the path at the point where the particle enters the counter. Now, range-*vs.*-curvature relations are among the best-studied of the features of the charged particles already known—electrons, protons, alpha-particles. These two points pertaining to the particle of Fig. 12 lie far from the curves appropriate to any of the three. An electron departing from the counter in a path of such a curvature as there is shown would have traveled 2,000 times as far before reaching the end of its course! a proton, on the other hand, only one seventy-fifth as far! This at the moment is deemed the sharpest and most clear-cut evidence for the existence of a particle intermediate in mass between proton and electron, to which Anderson now assigns a mass of 220 ($\pm$ 35) times the electron-mass.[13]

It is fitting to end this article by mention of several other kinds of evidence which have bearing on the question of the mesotron; mainly they are relatively indirect, and would require much space to describe and assess. Inferences have been drawn from the number of electrons ejected with high energy from metal plates by penetrating particles traversing these: J. G. Wilson derives a mass-value greater than 100. A curious inference has been drawn from the deflections suffered by these particles in traversing metals: the magnitude of these should by theory be independent of the mass of the particle—since it *does* appear to be the same for penetrating particles as for electrons, it is deduced that the mesotron and the electron can differ only in mass. Inferences have been drawn from the trend of cosmic-ray intensity with elevation in the atmosphere, and from the trend of cosmic-ray intensity beneath metal screens as function of the material and thickness of these last (it was thus that Auger as early as 1934 was led to suspect the existence of two kinds of charged particle among the rays).

Inferences have also been drawn from nuclear theory. To enter adequately into this difficult field is impossible here: it must suffice to say that Yukawa conceived, as a constituent of nuclear structure, of a particle possessing the charge of an electron and a mass of about the magnitude which the mesotron appears to have, and possessing in addition the quantity of *instability*. The "Yukawa particle," that is to say, has the qualities demanded of the mesotron, and in addition is liable to emit an electron; what is left behind is then a neutral particle which could elude observation. The emission is expected to follow the law familiar in radioactivity, the durations of individual Yukawa particles being distributed according to the law of chance about a mean value. Is there evidence that the mesotron behaves in this way?

For this there *is* some evidence, of the following kinds. First let us compare (in imagination) the number (per unit time per unit area) of penetrating particles flying vertically downward and the number flying obliquely downward. The comparison can be readily made with such an apparatus as that sketched in Fig. 3, the cloud-chamber being superfluous and the lead absorber reduced to the least thickness sufficient to stop electrons;

[13] Values diverging from this by more than the estimated uncertainties have been published by other observers of other particles, and may betoken an underestimate of the uncertainty or the existence of particles of several masses. A "nomograph" for facilitating the evaluation of mass from curvature of path combined with ionization-density or range is given by Corson and Brode.

the axis is oriented first at 90° and then at various lesser angles θ to the horizontal plane. Even the whole of the atmosphere is insufficient to stop such mesotrons as the cloud-chamber discloses; and yet the observations show a marked decline of the number thereof as θ decreases. But the particles which travel obliquely traverse a greater distance from the top of the atmosphere than those which come vertically down, and take a longer time in doing so; the decline of number with decrease of θ may therefore be ascribed to the perishing of the mesotrons *en route* to the apparatus as the route grows longer and longer. Second: Let us compare the effect of the obliquely traversed atmosphere with that of a sheet of lead in cutting down the number of particles arriving at the apparatus. One must make a guess as to the thickness of lead which would be required to produce a falling-off of the number of particles equivalent to that observed in the atmosphere, if the falling off were due to actual stopping of mesotrons in air and lead respectively, and the impermanence of the mesotron did not enter in at all. It is commonly conjectured that the equivalent thicknesses of lead and air would stand to one another inversely as the densities of these materials. When, however, the effects of such "equivalent" thicknesses are compared, it is found that the falling-off beyond the lead is decidedly less than that beyond the air. Now the mesotrons take very much less time for traversing the sheet of lead than the wide expanses of the atmosphere; and the "anomaly," as it has been called, is tentatively explained by assuming that few of them perish in the lead, many in the long journey through the atmosphere.

Estimates of the mean life of the mesotron thus made yield values of the order of a millionth of a second. It is supposed by many that the mesotrons are born in the upper layers of the atmosphere. Such conjectures, however, lead beyond the scope of this article, which must be confined to these few recent fruits of the seemingly exhaustless cornucopia of the cosmic rays.

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A BIBLIOGRAPHER TURNS DETECTIVE

HOW A BIBLIOGRAPHER OF FISH LITERATURE "RAN DOWN" AN OBSCURE CITATION TO ITS ULTIMATE SOURCE

By Dr. E. W. GUDGER

BIBLIOGRAPHER IN ICHTHYOLOGY, AMERICAN MUSEUM OF NATURAL HISTORY

As a professional bibliographer of fish literature, I have had from time to time the good fortune to "run to earth," in devious ways from obscure and misleading references, some very unusual and interesting things concerning fishes and fishing. And not infrequently I have been asked how I do it. For a long time I have had it in mind to describe some particularly interesting case, but always the press of work had led (if not compelled) me to let the thought pass by. However, I have just "run down" (with some expert help) the most interesting case I have ever tackled, and I am writing the story while it is fresh in mind.

For some months (since June, 1937) I have had a wonderful time studying the swordfish, *Xiphias gladius* (Fig. 1), from two points of view: its capture by the harpoon and its apparently retaliatory attacks on small boats and unprovoked ones on larger vessels. In this work I have dug up some exceedingly interesting and fascinating data. Thus Oppian (172–210 A.D.) in his "De Piscatu" published in 1478, but more accessible in the first English version as "Halieuticks or the Nature of Fishes and Fishing of the Ancients" (London, 1722), tells us that in the Tyrrhenian Sea and off Massilia (Marseilles) the fishers hunted for the swordfish in boats shaped like a swordfish—having a large ram-like prow, similar to the fish's sword, and on each side forward a large eye about where the hawse holes of a vessel are.

Now swordfish on calm sunny days delight to loaf along at the surface of the sea with the upper part of the body and particularly the sickle-shaped dorsal fin and the upper lobe of the great lunate caudal fin above water. Thus they are easily detected by the fishermen, particularly if (as is generally the case in Mediterranean waters to-day) there is in the boat a mast with a mast-head man on the lookout. In Oppian's day when a fish was detected, the boat was maneuvered alongside *Xiphias*, who was supposed to look up, and, seeing the deceitful mimic, would think to himself—"My big brother!" And then the striker would drive the cruel harpoon into his back.

This interesting procedure has been referred to by many writers on the fishing of the ancients, and has been figured by Victor Meunier in his "Les Grandes Pêches" (Paris, 1868, p. 147). Fig. 1 is a reproduction of this interesting conception of Meunier's artist.

This boat is the cleverest and most extraordinary fishing device I have found in a long study of such things. Its use seems to involve what the ethnologists call "sympathetic magic," and it would seem that this boat must have been widely used by ancient Mediterranean peoples.

Seeking confirmation of this fascinating story, I have waded through dozens of books dealing with and figuring classical antiquities, hoping to find in reproductions of Greek vases and Roman mosaics representations of such boats. But all in vain. Then with the help of the published "Bibliography of Fishes," I

began a search through the larger general works on fisheries. One of these is by S. B. J. Noël de la Morinière, and bears the title, "Histoire Générale des Pêches Anciennes et Modernes" (Paris, 1815). This I fell upon with joy, and I could hardly restrain myself when on the subject of swordfishing I read that, while it was known that the dolphin had often served the ancients as a model for their light rowboats, according to Pigafetta they had also constructed galleys in the semblance of a swordfish.

> This fish (Xiphias, Espadon), which we have seen at Constantinople, has a ram (or weapon) more than a fathom long, which is shaped like the prow of a galley. The fins on each side represent the oars, and the tail the rudder. The ancient Greeks had the custom of calling the poop the tail of the galley.

Ending the paragraph, of which the quotation above forms the larger part, are the cryptic words—"Pigafetta in notis italicis ad Leonis Tacticam, 291." From this, I jumped to the conclusion that Pigafetta must have seen not only the fish but the swordfish-shaped boats at Constantinople—or at least have heard of them there. So on to Pigafetta I marched.

Now the only Pigafetta I knew of was Antonio, a Venetian patrician and knight of the Order of Jerusalem, who went with Magellan on his great voyage. After the leader's death in the Philippines, Pigafetta came home and from his daily journal wrote a narrative of the circumnavigation. Since he was a great traveler, I felt sure that Antonio Pigafetta must be the man referred to by Noël. So I hastened to the Museum library and got an English version of Pigafetta's book—without an index.

In the absence of this, I did what I have done with many other indexless books—I went through it line by line. I found statements about other fishes, but none about swordfishes nor anything about Constantinople. At the New York Public Library, a line by line search through a better edition brought exactly the same results—nil. Back in our own library in the Museum, I found the latest and surely the best English version, if not the best edition in any language, of Antonio Pigafetta's "Magellan's Voyage Around the World." This version by James Alexander Robertson (Cleveland, U. S. A., 1906) is in three volumes with a splendid index. Moreover, it is provided with a wealth of scholarly notes which are a joy to read.

In these notes there were interesting data about various fishes, and better still of boats in the Far East fashioned like a dolphin; but no swordfish, nor boats at Constantinople shaped like them—nor indeed anything to indicate that our Pigafetta had ever been at Constantinople. But behold in "note 1" a ray of light. In a brief sketch of Magellan's

FIG. 1

historian, we are warned against confusing Antonio with Marcantonio Pigafetta, author of "Itinerario [da Vienna a Constantinopoli]," Londra, 1585. Whereupon, like the New England farmer, I became greatly "het up" and set out on a search for Marcantonio that very day.

The Museum library does not have the book, nor does the New York Public Library, nor the Library of Congress, but the catalogue of the British Museum shows that that great library has it. But, alas, the book has but 141 pages, whereas my reference seems to be to page 291. But I reasoned—"Perhaps my reference is to line 291 in a chapter headed 'Ad Leonis Tacticam.' ". So between the horns of this dilemma, I appealed to my friend, Dr. H. M. Lydenberg, librarian and director of the New York Public Library. He looked up the title in the British Museum Catalogue and telephoned me that he had put in an order for a microfilm of the book, "which will presently be available for your use."

Next morning, Dr. Lydenberg called again, but in a different vein, as may be gathered from the telephonic conversation.

"We have Marcantonio Pigafetta in Room 303 [Rare Books]."

"But it is not in the catalogue."

"No, it has not yet been catalogued, but as you know, in room 303 the books are arranged chronologically by centuries and are available if you know the year of publication—in this case, 1585.

"Great! Please have it got out for me that I may see it to-night."

"Since room 303 is closed at night, it will await you in room 300."

And later, hardly waiting to eat a bite of supper, I hurried down expecting to clear the whole matter up that very evening.

When I got down to the New York Public Library the book was ready for me but was in old Italian ("notis italicis"). Being obsessed with the idea that "Ad Leonis Tacticam" was a chapter heading or a marginal notation, I went over the little book page by page—with no results. Not yet discouraged, I went back next night and began a search through it *line by line*. This was slow work and I only got about half done. Another night I painfully perused the lines of the latter half. Results—exactly 0. Not yet discouraged but thinking that I must have overlooked the reference, and press of other work detaining me, I waited a week and perfectly fresh spent two more evenings with the same results. By this time I began to be considerably out of heart, but I waited another week and spent two more evenings painstakingly going over each line and noting those containing the words, fish and fisherman (in Italian), but nowhere did I find "pesce spada" (Italian for swordfish).

By this time it was clear that I was following an *ignis fatuus*, a false clue, but I determined to make one last attempt. So on Saturday afternoon, November 13, I went to the Public Library and to room 303. There the iron gate was unlocked for me and locked behind me, and Marcantonio's book was again put in my hand. I laboriously studied on every page previously noted every line containing the words for fish or fisherman. I could not translate the old Italian, but I could make out that there was surely no reference to any boats at Constantinople much less to one shaped like a "pesce spada." I was plainly following a false clue. Much discouraged, I said to Mr. Charles M. Adams, one of the curators in charge of the rare books, "I'm up a blind alley, a dead-end street, and there seems to be nothing to do but quit." And then, as sometimes happens in such desperate cases, help came.

Mr. Adams asked to see my notes from Noël de la Morinière, "Pigafetta in notis italicis ad Leonis Tacticam." To

my regret and chagrin be it confessed that, obsessed with the idea of their inclusion in Marcantonio's book, I had not critically considered the words apart and in themselves. This Mr. Adams did. "'Notis italicis' surely means notes in Italian. 'Leonis' must be the possessive case of Leo, a man's name. But what is 'Tacticam'?" A Latin dictionary gave no help. Then Mr. Adams produced Robert Watt's "Bibliotheca Britannica" and turned to the name "Leo." As I glanced down the page, I saw a Leo who was a geographer and who might have been at Constantinople. Grasping at a straw, I said "I must look through all those Leos." So I took the book, began at the head of the column, and presently the light broke through as sharp as a shaft of lightning. I read:

> Leo VI, the Wise, Emperor of the East [b. 865—d. 711].
> A Treatise on Tactics—Italice per Fil. Pighafettam, cum ejusdem Annot. Venice, 1586, 1602. 4°.

Light at last! And with difficulty did I restrain myself from upsetting the decorum of that reading room. But I did. And now I realized how absurd was my failure to translate "Leonis Tacticam" as "Leo's Tactics"—of which, however, I had never heard. Furthermore, I should have gotten a hint when in the British Museum Catalogue under Filippo Pigafetta I had read:

> Documenti . . . di Guerra . . . della Greca per M. F. Pigafetta. 1602. 4°.
> *See* Leo VI, called the Philosopher, Emperor of Constantinople.

This short title, because it did not contain the word "Tactica," did not register in the consciousness of this bibliographical detective. But the reference to "Leo VI, Emperor of Constantinople," should have sent me off full cry to the L volume of the British Museum catalogue. But, alas, I was obsessed with Marcantonio Pigafetta's travels to the city on the Bosphorus. So much for following a wrong clue.

Wringing Mr. Adams's hand *hard* for setting me on the track, and with a mounting blood pressure, I went hot foot to the catalogue of the Library of the British Museum to hunt for Leo VI, Emperor of Constantinople. But the only Leo VI I could find was the Pope of Rome. However, reasoning that Noël de la Morinière, a Frenchman, must have seen Pigafetta's book in the great Bibliothèque Nationale in Paris, I went to its catalogue with much confidence. But neither the 1586 nor the 1602 edition was listed. However, I did find editions of 1612 and 1613 done by Joannes Meursius and imprinted Lugduni Batavorum (Leyden of the Batavians—Holland).

Back to the British Museum catalogue, I hunted through *all* the Leos and presently found "Leo VI, The Philosopher of the East." Next I found not the 1586 edition by Filippo Pigafetta but one catalogued as follows:

> Leo VI, the Philosopher of the East.
> Documenti e avisi notabili di guerra: ne'quali s'insegna . . . tutta l'arte militare. . . . Redotta dalla Greca . . . par M. F. Pigafetta, con le annotationi del medesimo. Venetia, 1602. 4°.

At long last, I had the real clue in hand, and now for a transcript of the annotation.

Leo's "Tactics" had a great vogue. I have been able to trace in the catalogues of the British Museum, the Bibliothèque Nationale, the New York Public Library and the Library of Congress, 17 issues, editions and versions from 1586 to (strange to say) 1917. But when I sought the two earliest editions in the Library of Congress catalogue, I drew a blank. And so the 1586 edition not being available, but hoping that the same data might be found in the 1602 volume, on Monday, November 15, I sent a letter to Dr. Lydenberg asking him to request the

British Museum to examine the later, 1602, edition and, if Filippo Pigafetta's notes were found therein, to make and forward a photostat of the page.

However, just here, Mr. Adams did what I should have done—he wrote to the Library of Congress to ask that the book be located in the United States if possible through its tracing service. This was done and the 1586 edition was found in the library of Princeton University. A photostat of pages 292 and 293 of this book was made, sent to Mr. Adams and by him to me. Later, on a visit to Princeton, I examined this precious book and found no reference to *pesce spada* on page 291—Noël de la Morinière erred here. From this examination, it is clear that Pigafetta translated Leo's Tactics into Italian and at the end of each chapter added explanatory "Annotationi" of his own. The long-sought data are contained in a second set of "Annotationi" to chapter XVII and plainly have to do with naval matters.

And at long last, the photostat of the 1602 edition in the British Museum has come to hand. A comparison of the two photostats shows so far as page 292 is concerned the 1602 edition is a reprint, "verbatim, et literatim, et punctuatim" of the first edition.

And now for a translation. I can not read modern Italian, let alone the 1586 variety. But fortunately, to my colleague, Miss Francesca LaMonte, this old Italian is no puzzle and from her kindly made translation, the facts à la Pigafetta came forth.

It is evident that Leo's chapter XVII has to do with war galleys, and Pigafetta's notes state that there was a discussion of the origin of the galley and its beak or prow or ram. Pigafetta notes that many naval vessels are made to resemble the swordfish. "This is especially the case with the galley which both in name and form is like the swordfish (*pesce spada*) and which in Greek is called Galeotis [= Galiot]." Pigafetta states that he had seen the swordfish at Constantinople with its long sword like the beak of a galley. Then he quotes Aelian that the fish's beak was like that of a trireme, and like that of a trireme it was used to ram an enemy. "The fins which the galeote fish has placed on its body are represented by the oars of a galley and its tail by the rudder. The ancient Greeks used to call the poop the tail of the boat. Thus the parts and the name of the fish Galeotis correspond to those of the boat Galeotta."

But now that the Pigafetta reference has been run to earth, it is surprising and disappointing to find that Pigafetta did not seem to know of Oppian's story of the use of the swordfish-shaped boat for harpooning and capturing the swordfish. Of Filippo Pigafetta (1533–1603) I have been able to learn little in the bibliographical sources available to me. He was a historian, traveler and military engineer who published a book on the history and use of the compass. He was chamberlain to Pope Sixtus V and was sent by him on a political errand to Persia. He seems to have edited and published several books of travel.

Thus, after following many false clues, my search has ended successfully. It is absurd that these clues should have led me astray, but following them I have at least chanced upon sources of data bearing on the history of the development, the evolution, so to speak, of the swordfish shaped swordfishing vessel and of the long, beaked galley. I hope presently to find time to study this material and prepare a short article.

LACEWINGS AND THEIR ALLIES[1]

By Dr. LEE H. TOWNSEND
COLLEGE OF AGRICULTURE, UNIVERSITY OF KENTUCKY

THE group of insects to which the lacewings and their allies belong is known as the Neuroptera. Perhaps the most familiar of these insects to the average person are the small green lacewings which are found upon herbage and upon the foliage of trees and shrubs during the summer months. Some of these are attracted to lights and gain entrance to our homes on summer evenings.

The Neuroptera as now understood by most authorities are far different from the heterogenous group which formed the Neuroptera of Linnaeus. His group is now divided into several well-defined divisions called orders. The original name (Neuroptera) is confined to the suborders Megaloptera and Planipennia as used by Imms and by Tillyard in their text-books. Megaloptera which means "large wings" contains the alder flies and snake flies whereas Planipennia means "flat feathers" and contains the lacewings, ant lions and their allies. The latter suborder contains the greater number of species or kinds. Australia has a more complete and varied fauna of Planipennia than any other region of the earth, the only absent families being the Dilaridae and Polystoechotidae. The Neuroptera are divided by some authorities into two or three separate orders but it is difficult to find constant characters with which to support such a separation. Comstock, in his well-known text-book, limits the group as do Imms and Tillyard but he does not use the subordinal names. The larvae, or young, and adults separate very readily into the two suborders and it appears that this arrangement is a logical one.

[1] Published by permission of the dean of the College of Agriculture, University of Kentucky.

The known Neuroptera of the world represent about twenty families, depending upon the limits imposed by the different workers. Thirteen of these families are represented in North America.

The Megaloptera fall naturally into two distinct groups, the "alder flies" and the "snake flies." These are small groups and include a small number of archaic types which do not seem to be very closely related among themselves.

The alder flies include the most generalized members of the Neuroptera and are of interest on account of the large size and striking appearance assumed by some of the species. As often in primitive groups, there is only a small number of species or kinds, but they have an almost world-wide though discontinuous distribution.

The eggs of these insects are laid upon leaves, stones or other objects usually not far from water. They are generally deposited in compact masses and the number of eggs in each mass may vary from two hundred (*Sialis*) to two or three thousand (*Corydalus*). The eggs are cylindrical with rounded ends and at its free extremity each is provided with a conspicuous projecting apparatus which varies somewhat in the different groups. After hatching, the young larvae make their way to the water and according to their kind seek the muddy bottoms of ponds or slow-moving streams or maybe stones under which to hide in rapidly flowing water. All the larvae (Fig. 6) of the alder flies are predaceous, that is they devour other insect larvae, small worms or in fact any small animal life that comes their way. These larvae possess paired, lateral filaments on most or on all of the abdominal segments. Some

of the larvae (*Corydalus*) are called "dobsons" or "hellgrammites" by certain anglers who use them for bait. These larvae remain in this stage about two years and eleven months before changing to the next stage or pupa. The pupal stage occurs in the soil, moss or perhaps under the bark of a rotten log or stump near the water. Although the pupa may be buried several inches it is able to work its way to the surface so the adult may appear. In *Corydalus* the wing-expanse may range up to 150 mm.

The snake flies are the most specialized members of the Megaloptera and are entirely terrestrial in habits. This group is present on all the continents except Australia. The larvae (Fig. 10) of the snake flies (Raphidiidae) resemble very much the larvae of certain ground beetles (Carabidae) and are predaceous. They live under bark and in North America are restricted to the West. The adults are strange-appearing insects in that the region of the body just posterior to the head is greatly elongated. The fore-legs resemble the other pairs of legs and are borne at the hind end of this elongated body region, the prothorax. It is this elongated prothorax which gives these insects their common name "snake flies."

The Planipennia include the majority of the Neuroptera, and here we find the true lacewings and most of the familiar members of the order. Many of the families are very different in their adult characters, but the group is well defined on account of the universal occurrence of the piercing suctorial mouth parts in the larvae or young (Figs. 1, 2, 3, 5).[2] Nearly all the Planipennia are terrestrial insects, but a small number are more or less amphibious as larvae, and a few have truly aquatic larvae. So far as known only one North American family (Sisyridae) has aquatic larvae. These are the spongilla flies and will be described later.

So far as known all the larvae of the Planipennia are predaceous and are of importance as destroyers of aphids and other soft-bodied injurious insects. The head is generally large and freely joined to the next body division, the prothorax. Two pairs of the mouth parts, the mandibles and the maxillae, are long and exserted. The mandible and maxilla of each side form an organ for piercing and sucking. These appendages are long, sickle-shaped, sometimes armed with internal teeth, curved at the distal end and well fitted for grasping and piercing the body of the prey. The combined mandible and maxilla of each side fit together and form a tube through which the liquid contents of the victim's body is sucked. This general type of mouth parts is common to all known larvae of the Planipennia.

The larvae of the Megaloptera do not form a cocoon in which to pass the pupal or resting stage of their development but merely hollow out a cell as their place of abode for the time being. The Planipennia, on the other hand, pupate in a cocoon or covering. The silk of which these cocoons are made, in those in which the silk organs have been described, is secreted by modified Malpighian vessels and is spun from the anus. The Malpighian vessels are excretory tubules which open into the beginning of the hind intestine. The silk-organs of *Sisyra* have been described by Miss Anthony in the *American Naturalist* (1902).

The mantis-like Neuroptera or Mantispidae are among the strangest in appearance of any of this group of insects. The prothorax or second body division is greatly elongated. The remarkable fore-legs are fitted for seizing prey, and in order that they may reach farther forward they are joined to the front end of the long prothorax. This is opposite to

[2] After Townsend, "Key to larvae of certain families and genera of nearctic Neuroptera." Proceedings Entomological Society of Washington, 37: 25–30, 1935. Drawings were made by Dr. C. O. Mohr, associate entomologist, Illinois Natural History Survey.

the condition found in the snake flies, where the fore-legs are joined to the hind end of the long prothorax. The adults of the Mantispidae are predaceous and the larvae, so far as is known, are parasitic. The development of these insects is peculiar in that the larvae differ in appearance at different ages. They do not merely increase in size as they grow older but the appearance changes completely. This type of growth is called hypermetamorphosis. Very little has been done on the life history of these insects, but it has been demonstrated that a European species lives in the egg-sacs of spiders of the genus *Lycosa*, while the larva of a South American species lives parasitically in the nests of wasps. Dr. R. C. Smith has reared an American species from the egg-sacs of a spider in Kansas. Not many species of this family occur in the United States and all are rare insects.

As previously stated the larvae (Fig. 5) of the spongilla-flies are aquatic. They live in fresh-water sponges upon which they feed. Excepting the alder flies and certain of their allies of the Megaloptera, these spongilla fly larvae are the only known aquatic neuropterous larvae found in North America. When full grown the larva leaves the water and on some object nearby spins over itself two cocoons of silk. One of these cocoons just covers the larva and the other is somewhat larger. The life history of two species of these interesting insects was worked out by Professor J. G. Needham in New York State.

The family Chrysopidae includes the lacewings or aphis lions, and as already stated these are probably the best known members of the group. The adults are most easily recognized by their delicate lace-like wings and their green or yellowish green color. These insects are sometimes called golden-eyed flies on account of the metallic color of their eyes in life. Some of the species when handled give off a rather disagreeable odor and have been called stink-flies, a rather unfitting name for such beautiful insects.

The larvae (Fig. 3) of these insects are known as aphis lions because they feed mainly upon aphids. They can generally be found upon plants which are infested with aphids, though they also feed upon other small, soft-bodied insects as well as insect eggs. They are somewhat spindle-shaped and have the type of mouth parts already briefly described for the Planipennia. A few species of aphis lions cover themselves with debris and are thus known as trash-carriers though most of them are naked. A trumpet-shaped structure (empodium) (Fig. 9) is present between the tarsal claws of these larvae.

An interesting fact in the life history of these insects is the way in which the female cares for her eggs. Just before laying an egg she emits from the end of her body a minute drop of a tenacious substance which she applies to the object on which she is standing. She draws this substance out into a slender thread by lifting the hind part of her body; then an egg is placed on the summit of this thread. The thread dries almost immediately and holds the egg in mid-air. The eggs of Mantispidae are also fastened upon stalks.

The cocoons are composed of dense layers of silk and are generally found on the leaves or supports of plants. Before emerging the insect cuts a circular lid from one side of the cocoon. This is done by the pupa, which crawls about for a short time before changing to the adult.

This is one of the larger families of the Neuroptera, there being about fifty species or kinds of lacewings in the United States and Canada. An attempt has been made to introduce a species of lacewing from Canada into New Zealand, where this beneficial family is absent, but as yet no information is available as to the success or failure of this venture.

The Hemerobiidae are often called

brown lacewings on account of the color of the wings of most of our species. Both the larvae and adults resemble in general appearance the Chrysopidae or green lacewings. The larvae of the Hemerobiidae, in so far as known, have the predatory type of mouthparts, already described, and feed on soft-bodied insects, especially aphids, by sucking the liquid contents of the body. The food habits are practically the same as for the aphis-lion or larva of the Chrysopids.

The name "Large Lacewings" has been applied to the member or members of the family Polystoechotidae. This family is confined to North America and excepting Sialidae contains our largest Neuropteron. The adults are very hairy, blackish and with large, broad wings. These specimens are 30 mm long to the tips of the wings and the expanse is from 40 to 75 mm.

It is strange that the larva of this large insect has never been recognized in the mature state. J. G. Needham, H. B. Hungerford and P. S. Welch have obtained eggs from females kept in confinement. Hungerford describes the eggs as follows: "The eggs are rather soft shelled and easily collapsed. While they appear chalky white to the unaided eye, under the binocular they are opalescent with a tiny chalky white button-like micropyle at one end. This characteristic reminds one somewhat of the eggs of *Chauliodes*, one of the Sialids." He further adds that the eggs are 1.02 mm long, and .48 mm wide. Welch, in his paper, gives information, not only concerning the egg, but about the newly hatched larva as well. This larva seems to be of a rather primitive type and it was most unfortunate that it could not have been reared.

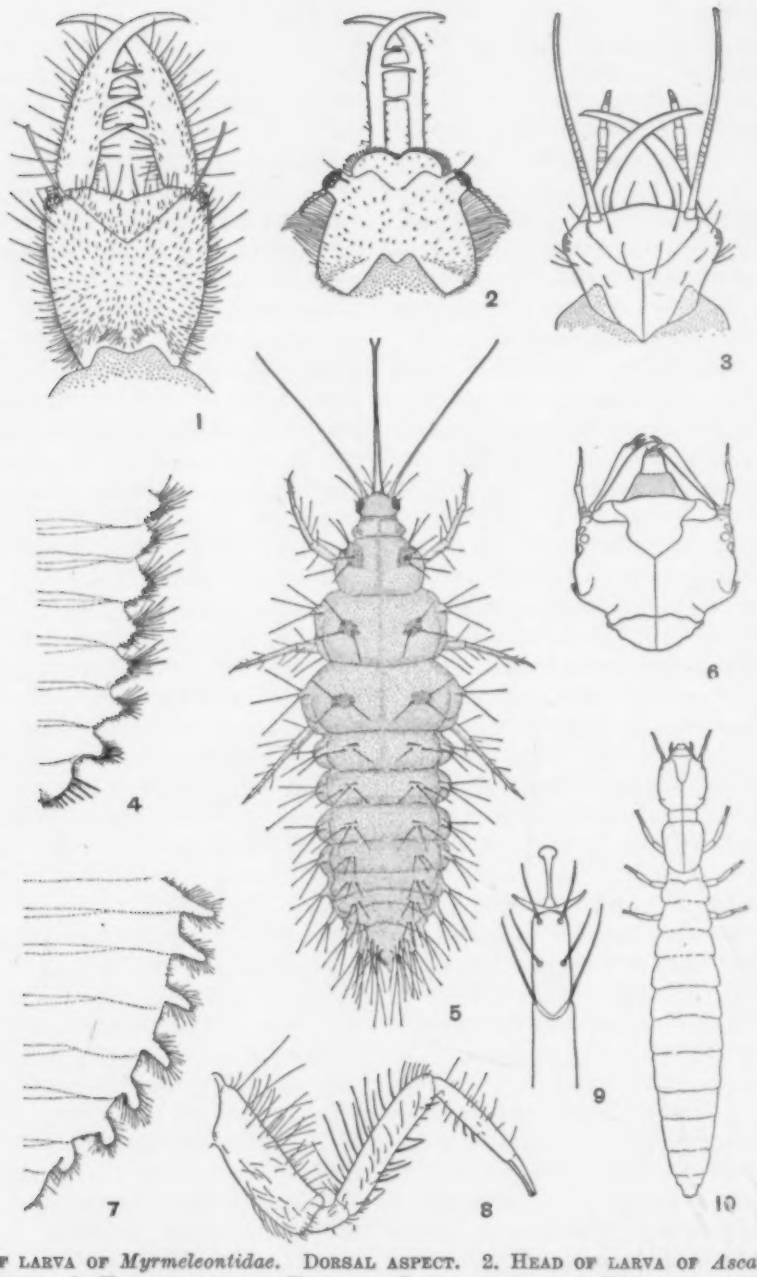
The Ant-lion Lacewings (Myrmeleontidae) are the dominant group of the order. This family is perhaps better known from its familiar larval forms, called "ant-lions" or "doodle bugs" rather than from the slender, delicate adults. The larvae (Figs. 1 and 4) are stout, with large jaws curving inwards distally and having at least three internal teeth on each mandible. Most of them live hidden in sand or debris.

These larvae are much more common in the southern and southwestern states than in the north. As the name suggests the ant-lions dig pitfalls and feed chiefly on ants. The pitfalls are usually found in sandy places which are protected from rain, as beneath buildings or protecting rocks. The larvae in making these pitfalls throw the sand out by an upward jerk of the head, which part of the body serves as a shovel. The pits differ in depth according to the kind of soil in which they are located and their sides are generally as steep as the soil will lie. When some wingless insect such as an ant steps upon the edge of one of these pits, the sand crumbles beneath it and it falls into the jaws of the ant-lion which is buried at the bottom of the pit.

The pupal or resting stage is passed in a spherical cocoon. This cocoon is made of sand fastened together with silk and is lined with the same material.

The life-histories of very few species are known. Not all the species have larvae which dig pitfalls, but these last have attracted much attention since the beginning of entomology.

The family Ascalaphidae is closely related to the Myrmeleontidae but is more restricted to tropical and subtropical regions. Both the larvae and adults of the former are larger and more robust than corresponding stages of the latter. The adults can readily be distinguished from the adults of dragon-flies which they resemble by their long, clubbed antennae. The larvae (Fig. 2) of the Ascalaphidae in common with the larvae of the ant-lion have the hind tibia and tarsus (Fig. 8) fused to form a single joint. This occurs also in the larvae of the Ithoniids and in addition these have this fusion in the first and second pairs



1. HEAD OF LARVA OF *Myrmeleontidae*. DORSAL ASPECT. 2. HEAD OF LARVA OF *Ascalaphidae*. DORSAL ASPECT. 3. HEAD OF LARVA OF *Chrysopa*. DORSAL ASPECT. 4. RIGHT HALF OF ABDOMEN OF LARVA OF *Myrmeleontidae*. DORSAL ASPECT. 5. ENTIRE LARVA OF *Sisyra* SP. DORSAL ASPECT. 6. HEAD OF LARVA OF *Corydalus cornutus* LINN. DORSAL ASPECT. 7. RIGHT HALF OF ABDOMEN OF LARVA OF *Ascalaphidae*. DORSAL ASPECT. 8. RIGHT METATHORACIC LEG OF LARVA OF *Myrmeleontidae*. 9. TARSUS OF LARVA OF *Chrysopa* SP. 10. ENTIRE LARVA OF *Raphidia* SP. DORSAL ASPECT.

of legs as well. In general appearance the larvae of the Ascalaphids and Myrmeliontids are much alike. The head (Fig. 2) of the former is much broader and the abdomen (Fig. 7) has laterally produced segments. The body setae are short, stubby and longitudinally fluted in the Ascalaphids but are long, slender bristles in the ant-lions. Some species of Ascalaphids lay their eggs in regular rows on plants. In these, certain structures which are really imperfect eggs are placed as blockades around the stem below the eggs and have been regarded as a protective device. The larvae lie in wait for their prey and normally walk forward though they can also walk backward. The older larvae may turn cannibal and eat their own brothers.

The Ascalaphid larva when full-grown spins a spherical cocoon more or less covered with bits of leaves and twigs. The adults are crepuscular.

The family Coniopterygidae includes perhaps the smallest of the Neuroptera. They are rather fragile insects and bear a general resemblance to aphids. The body and wings are covered by a whitish powder. The wing venation is quite simple, being greatly reduced as compared with other Planipennia. The adults resemble slightly other neuropterous insects but the strongest claims which these insects have to be considered neuropterous are the structural characters of the larvae.

The larvae feed upon aphids, scales and probably other such small creatures. They are short and taper towards the hinder extremity. The mandibles and maxillae are short, stout, piercing organs and the labial palps are prominent, flattened appendages which project in front of the head. The larvae pupate in a cocoon spun of silk emitted from the anus as in other Planipennia. The members of this family, all of which measure 3 mm or less, are not rare but need careful looking for and, up to the present, only about eight species have been found in North America.

So far all the groups that have been mentioned have been found in North America. Not necessarily there alone, but at least they are native with us. Now will be mentioned briefly several families which are not present in North America but are especially interesting.

The Ithonidae or Moth-Lacewings is an interesting neuropterous family in that it more nearly bridges the gap between the Megaloptera and Planipennia than any other known family. This family is confined to Australia, as are several other groups of very interesting animals. The males have large, forcipate appendages, while the females are larger and carry a peculiar sand-plough for use in laying their eggs in sandy soil, rolling each into a small cocoon of sand-grains. The larvae resemble white grubs but have strong burrowing legs. They emit a pleasant odor of citronella. They attack Scarabaeid larvae and other insect grubs in the soil with their short, upcurving, sucking jaws. These larvae probably have some economic value, but attempts to introduce them into other countries have so far failed.

The Psychopsidae or Silky Lacewings is a family of very beautiful insects which has existed almost unchanged since Triassic times, and with its headquarters in Australia. A few species occur also in Africa, India and China. Most all the species are of striking beauty.

An extraordinary group of lacewings is the family Nemopteridae. The head is prolonged forwards into a rostrum, the only family of the order which shows this character. The hindwing is remarkably specialized, being long and narrow. This wing is either ribbon-like, or with one or two expanded parts, more or less spoon-shaped. The forewing has much the Myrmeleontid type of venation. The larvae

live in sand or debris, have a stout body and a long slender neck. Their jaws may or may not have internal teeth. This family is confined to Africa, Madagascar, South Europe, India and Australia.

The larvae of the family Osmylidae live under stones, about moss or some other situation either in or near the water. These larvae have long stylet-like mandibles and maxillae which curve slightly upward. Unlike *Sisyra*, already mentioned, they have no gills but breathe by means of thoracic and abdominal spiracles. It has been reported that the natural food consists of dipterous larvae. The adults occur along the borders of clear streams where there is a dense growth of bushes.

There are several excellent examples of sexual dimorphism in the Neuroptera. The dimorphism referred to here is a structural difference between the sexes other than that concerned in the genitalia or external sexual parts.

The male *Corydalus* has enormously elongate, sickle-like mandibles. The female resembles the male in most respects but her mandibles are comparatively short.

In the lacewing *Meleoma signoretti* there is a striking sexual dimorphism. The head of the male bears a prominent frontal horn, and this supports a brownish, ventral brush of hair.

The members of the genus *Psectra* of the Sympherobiidae are of interest in that the female has the usual four wings whereas in the male the hind wings are atrophied. Each wing is represented only by a small scale.

The only North American species of Dilaridae, *Dilar americanus*, has a male of which the antennae are pectinate. It is interesting to note that the female is furnished with an exserted ovipositor, the length of which is a little greater than the length of the body. This same statement applies to the female of the Raphidiidae or "snake flies."

It is obvious that throughout this discussion emphasis has been placed on the larval stages. The habits of these larvae or young are most interesting, living as they do in a variety of situations. Their place of abode includes various habitats from water to the egg sacs of spiders. About the only thing all have in common is the carnivorous habits. So far as known this holds true for all larvae of the order.

In so much of our entomological work the emphasis has always been on the adult stages. True there is much here to be done but the immature stages of practically any group of insects offer a fruitful field for investigation.

Knowledge gained from a study of the immature stages of any group of insects would probably shed light on the classification and grouping of the adults. In no group is this better shown than in the Neuroptera. So far as the larger groups such as suborders and families are concerned the larvae furnish better characters for separation than the adults. At the present time the classification of the order is based very largely on wing-venation and this does not always hold. For example based on wing-venation the small family Coniopterygidae could hardly be placed in the Neuroptera at all. It is often stated that the larval characters enable this family to be placed in the order under discussion.

Notwithstanding the way in which the Neuroptera of the Linnaean classification has already been divided as mentioned in the early part of this discussion, some authorities claim that even yet the Neuroptera represent several lines of evolutionary descent from the ancestral stock whatever that was. It is easy to see that this order exhibits at least two distinct lines of evolution. Going back to the undifferentiated ancestors of the order, one branch arose and made up the suborder Megaloptera. This is divided into two well-marked families, the "alder-flies"

(Sialidae) and the "snake-flies" (Raphidiidae). The chewing mouth-parts of the larvae (Figs. 6 and 10) better characterize this suborder than any characters of the adults. The Sialidae is certainly the more primitive. Some authorities are of the opinion that each of these families should be placed in an order to itself.

Another line of evolution leads to the suborder Planipennia and thus to the greater number of the Neuroptera. The various members of this suborder exhibit many and varied characters but so far as known all agree in that the larval mouth-parts are constructed on the same plan (Figs. 1, 2, 3 and 5) and no maxillary palps are present. The details and shape of the mouth-parts may differ somewhat but in no other group of insects is the channel through which the liquid food is taken into the body composed of the combined mandible and maxillae. This type of mouth-parts has already been briefly described.

The larvae, so far as known, of both suborders separate readily into families. Characters for the recognition of species may not always be available among the larvae but this should in no way detract from their value in diagnosing larger categories.

It is the hope of the writer that he has helped to demonstrate the importance of the immature stages in a classification of insects, by the example of the Neuroptera. He does not advocate basing a grouping on the larvae alone, but is of the opinion that they might aid in many cases.

CAUSES OF VIRUS DISEASES IN PLANTS

By Dr. MELVILLE T. COOK

PLANT PATHOLOGIST, AGRICULTURAL EXPERIMENT STATION, RIO PIEDRAS, PUERTO RICO

THE progress in our knowledge of any science or branch of science goes through an evolutionary development which is as interesting as the evolutionary development of any group of animals or plants. When this occurs within the lifetime of a generation it becomes especially interesting to the research students of that period. This is true of the advancement of our knowledge of the viruses that cause diseases in plants, and which has come to our knowledge within the last half century. The studies of these diseases, like all other studies, have been greatly influenced by the progress in other sciences. Although a few of these diseases have been known for a very long time, the research studies were started by Mayer a little more than a half century ago and the first paper on this subject was published by him in 1882, although the most important paper was not published until 1886. Mayer was evidently influenced by the science of bacteriology which was attracting so much attention at that time. His studies were made on the mosaic disease of tobacco which had been known for some time and which was the first of the virus diseases to be recognized as of great economic importance. He appears to have been convinced that this disease was caused by bacteria, although he did not succeed in isolating an organism. Dr. Erwin F. Smith, who contributed so much to our knowledge of bacteria as the causes of diseases of plants, was studying the yellows disease of the peach in the United States at about the same time that Mayer was studying the mosaic disease

of tobacco, and in his first paper, published in 1888, he said:

> The spread of yellows from diseased buds to healthy stocks, which I have carefully verified, points strongly to some contagium vivum as the cause of the disease. If a micro-organism be really the cause, it probably occurs quite constantly in some part of each diseased tree, and this must be established beyond question; it must also be clearly distinguished from similar organisms not related to the disease; and, finally, it must be isolated by cultivation in suitable nutritive media and be able to produce the disease when inserted into healthy trees. If from a pure culture of some micro-organism peach yellows can be induced in healthy tree, then the case is closed and there can be but one verdict.

Iwanowski (1892), who also studied the mosaic disease of tobacco, believed that it was caused by bacteria. He discovered that the active agent would pass through a Chamberland filter but was so firm in his belief that the causal agent was a bacterium that he did not understand or appreciate the importance of this discovery, which was to attract so much attention in future years. He believed that the disease was caused by an organism which was so small that it could pass through the filter.

Beijerinck (1898) was the first to oppose the bacterial theory. He confirmed the filtration experiments of Iwanowski, but insisted that the liquid which passed through the filter did not contain bacteria. As a result of these studies he advanced his theory of a "contagium vivum fluidum" which lived parasitically in the cells of the host plant.

Iwanowski published another paper in 1903 in which he opposed the work of Beijerinck and insisted on the bacterial theory.

The bacterial theory has persisted with greater or less vigor for many years and has come forward in many papers, but has been surrounded with doubt since the work of Beijerinck. His "contagious living fluid" theory offered a very ingenious explanation of the increase of the causal agent but was not accepted by many students of the problem. However, this theory had its influence on the studies and literature and as late as 1925 Kunkel said:

> From this brief consideration of the hypotheses it is seen that we do not yet possess a better one than that which assumes a living fluid contagium. When Beijerinck formulated his conception he believed that the virus of tobacco mosaic could pass to some depth into solid agar plates. We now know that he was in error in this respect. The virus does not pass through the agar. We are therefore led to believe that the causative agent although filterable is nevertheless corpuscular. Beyond the fact that they are filter passers we know little about these corpuscles. They are doubtless very minute but perhaps not ultramicroscopic. Plasticity rather than size may account for their filterability.
>
> It would be folly to speculate as to what these corpuscles are like, but I wish to suggest that they are probably of the nature of living cells.

The next was the enzyme theory, which was advanced by Woods (1899) and Heintzel (1900), who developed this theory independently. By this time the study of enzymes was attracting much attention among the research students of the biological sciences, and Woods was evidently influenced by these studies. His idea as to the origin of the active agent appears to be expressed in the following statement:

> It is evident, therefore, that the zymogen exists in the cell in sufficient quantity to regenerate practically the same amount of active enzyme as is already in the cell. The transformation of the zymogen into the active enzyme takes place whenever the active enzyme in question is removed or destroyed.

This theory was very generally accepted by many students and has had a marked influence on the studies of these diseases for many years. However, it was questioned by several students, especially by Allard (1912–15), who said that the "facts strongly suggest the presence of a living active micro-organism."

Hunger (1902–1905) opposed the enzyme theory and advanced the theory of

a "non-living toxic ferment" which was always present in healthy plants and which increased when the conditions were unfavorable for the nutrition and growth of the plant. This theory assumed that the ferment was the product of the plant cell. It did not attract much attention or receive much support.

Before leaving the enzyme theory it is interesting to note that Penhallow (1883) reported that peach trees infected with yellows contained more enzyme than healthy trees, but it is evident that he confused yellows trees with frost-injured trees.

Mayer (1886) said that:

> A chemical ferment seems probable. This sort rarely causes a disease, and it is unheard of that an enzyme multiplies for itself. An organized ferment might be a fungus or a bacterium.

Protozoa-like bodies, often referred to as inclusion bodies, intracellular bodies and X-bodies, were known long before the development of the protozoan theory. Iwanowski found them in the cells of mosaic tobacco plants in 1900, but believed them to be the results of the disease. Delacroix reported the results of some studies on these bodies in 1906, and Lyon described similar bodies in sugarcane infected with Fiji disease in 1910. However, no one suspected similarity between the tobacco mosaic and the Fiji disease, and these bodies did not attract much attention until 1921, when Kunkel published a paper in which he described intracellular bodies in the chlorotic areas of mosaic corn and suggested that they were living organisms and the possible causative agents of the disease. This paper led to studies on several of the virus diseases and to the discovery of similar bodies associated with several of them. During this same period flagellate-like bodies were reported associated with several of the virus diseases. The fact that protozoa are known to be the causal agents of many diseases of animals, including man, influenced and stimulated these studies. However, these bodies could not be found associated with all types of virus diseases, and the theory was questioned by many research students. At the present time we do not have any positive evidence that these bodies are the causes of diseases, but their presence in a diseased plant is considered positive proof of a virus disease.

The virus theory, unlike the other theories, can not be very definitely associated with any one worker. The term "virus" is from the Latin and originally referred to a poison, but has lost this meaning in relation to this group of diseases. It has been used by the medical profession for many years in connection with smallpox and other diseases. Baur (1906) expressed the belief that the causal agent was a non-living, highly organized product of metabolism which he called a "virus." So far as the writer has been able to learn, Baur was the first to use this term to designate these diseases. The term was used with variable meanings during the next few years. Some workers assumed that it was a living organism, an ultra-microscopic organism or a something made up of inconceivably small particles. In fact, the students accepted the name "virus" for an active, causal agent which they did not understand, and the research studies were directed at the determination of the characters and properties of this agent. This resulted in studies on dilutions and on reactions to temperature and chemicals which contributed much to our knowledge of the subject but did not give a very definite explanation as to the causes of these diseases which were attracting more and more attention. We are now using the term "virus" with a meaning entirely different to that in which it was originally used, and it will probably persist as a name for these diseases.

The behavior of the viruses was so

similar to that of living organisms and the reactions of the host plants so similar to the reactions of plants attacked by living organisms that many of the workers had come to consider these so-called viruses as living organisms. Of course it should be remembered that nearly all the students of these diseases had been trained in the biological sciences and very naturally assumed that these diseases were caused by living organisms and directed their research studies accordingly.

However, there were some workers who questioned the living organism idea, and these doubts gave rise to studies which resulted in the chemical theory. In this connection we should remember the theories advanced by Woods, Hunger and Baur to which we have referred. The chemists who have done so much during the past ten or twelve years to advance our knowledge of this subject were not influenced by the living organism idea that had influenced the biologists. They attacked the problem from an entirely different view-point. Vinson and Petri (1927–1934) published the results of studies in which they had precipitated a substance from the juice of mosaic tobacco by the use of safranin and other chemicals. This substance would produce the disease when injected into healthy tobacco plants. These precipitates were not pure, but contained traces of nitrogen. Barton-Wright and McBain (1933) gave us the results of studies on the mosaic tobacco plants by which they had isolated a white crystalline compound without nitrogen which would also produce the disease when injected into a healthy tobacco plant. Caldwell (1934) published the results of studies in which he followed the methods of Vinson and Petri and of Barton-Wright and McBain and said, "I have found no evidence that the crystals contain virus except as an impurity."

The studies of these research students were followed by a series of papers by Stanley from 1934 to the present. He was able to isolate a protein crystal which proved to be extremely virulent when injected into healthy tobacco plants. These crystals were prepared first by the use of chemicals and later by the use of ultracentrifuge. Similar results have been obtained in the studies of some of the other viruses of both plants and animals. These protein crystals appear to be produced autocatalytically in the cells of the host plants, to possess a high molecular weight and are extremely variable in stability.

The recent studies which have given rise to the chemical theory call to mind that Iwanowski found crystals in the cells of mosaic tobacco plants and that the description of the active agent of tobacco mosaic written by Beijerinck is exceptionally good. They also call to mind that Woods, Hunger and Baur believed the active agents of tobacco mosaic was produced in the cells of the host plants. However, there are some workers who believe that the cells of the host plants produce the active agent as a result of stimulation.

Stanley from the very first has admitted the possibility of the protein crystals being carriers of an active agent and in 1938 said:

> The possibility that the activity may be due to an impurity must always remain, regardless of the material under discussion. However, since there is no reason to believe that such a situation actually prevails in the case of the virus protein, we are unable at the present time, to conclude other than that the high molecular weight protein under discussion is the virus. Now these same tests that indicate that the virus protein is homogenous may be used to demonstrate that it possesses the ordinary properties of molecules. As a matter of fact, the chemists, after a perusal of the physical and chemical properties of the tobacco mosaic virus protein, has no difficulty whatsoever in coming to the conclusion that despite its huge size, it has all the properties of a molecule and hence is a molecule.

Bawden and Pirie (1937) isolated liquid crystalline nucleo-proteins from tobacco mosaic and two cucumber mosaic viruses, which indicates that they are the same or very similar to the nucleo-proteins obtained from nuclei. This has been confirmed by other workers and raises the question as to the relationship between a virus and a gene.

It has been suggested by Green and later by Gortner that a virus might be an internal parasitic organism that has lost its power to produce protoplasm but persists as nuclei living in the protoplasm of the host cell. If this theory is correct, it is very easy to account for the fact that the virus is restricted to the cells of certain plants and for the mutations which have been reported for a few viruses.

We should not close this review of the subject without calling attention to the gene theory which was suggested by Duggar and Karrar (1923), who said that a virus might be:

> . . . a particle of chromatin of some structure with a definite heredity, a gene perhaps, that has, so to speak, revolted from the shambles of coordination, and being endowed with a capacity to reproduce itself, continues to produce disturbances and stimulation in its path, but its path is only in the living cell.

Lesley and Lesley (1928) reported a wiry tomato which resembled a mosaic tomato and said that "it is hereditary in nature and probably due to a gene mutation."

Holmes (1934) reported experiments with *Capsicum* and *Nicotiana* which indicated that a single dominant gene was responsible for the localization of tobacco mosaic virus.

Riddle (1936) called attention to the fact "that both the virus molecule and the genes are known to have the capacity to duplicate themselves exactly." He also stated that "there is strong evidence that the gene is a single molecule and that it is a protein molecule."

Kostoff (1936) made a very interesting comparison of a virus and a gene and concluded by saying:

> Some of them coincide, others are similar and some others somewhat different. It is very unfortunate that we do not yet know such essential characters according to which we can definitely establish the degree of relationship between genes and viruses. Until that time we have no right to claim that genes are identical with viruses. It is better now to leave this question open, instead of drawing conclusions. We can only say that in many respects the effect of the virus is similar to that of the gene.

McKinney (1938) said:

> It is possible that the virus represents a filterable form of some larger organism, or it may represent a degenerated organism which has retrograded by a series of mutations to a stage where a few genes or perhaps a single gene remains to perpetuate as virus.

Holmes (1937) reported four types of symptoms on *Capsicum frutescens* when infected with tobacco mosaic virus, distorting strains which he believed were controlled by three different genes.

All these theories have had their supporters, but no one of them has been accepted by all the workers, and it may require several years to demonstrate that any one of them or some entirely new theory is correct.

CHLOROPHYLL—ITS FUNCTION

By Dr. FRANK MILTON SCHERTZ
WASHINGTON, D. C.

EVER since man has had the power of sight he has known that Nature annually paints the surface of the earth green. Nature's annual paint bill includes roughly two thousand million tons of green pigment and 300 million tons of yellow. The function of these two and a third thousand million tons of colored organic plant material has long been the concern of scientifically minded men.

As scientific thought has progressed, man's conception of the rôle of these green and yellow pigments has undergone change, and the change has been in proportion as he has gained knowledge regarding the other processes of nature. For no part of man's conception of life and of living things can proceed without deeply affecting his other conceptions of the nature of himself and of the physical world. In our time there have been vast changes in man's conceptions of the physical universe. These conceptions in turn are bearing fruit by affecting our other interpretations of life. In troubled times like these man is in need of new ideas, new conceptions and a new manner of life.

A study of the chlorophyll problem offers numerous possibilities, and it is these possibilities that are worthy of our serious consideration. Test-tube experiments concerning these pigments are highly interesting to scientific investigators, but thoughts concerning these pigments become of vastly greater interest when these thoughts begin to take on aspects that affect man's conception of his universe. They lead to enlightening knowledge which tremendously affects his own future.

With these thoughts in mind let us turn to our subject, which at present is only in an evolutionary state of development. If we have learned how very little we really know then we truly have accomplished something. It is that little that we know which is to be given consideration here.

We are aware that in some way chlorophyll is bound up with energy and with light and that it has something to do with the production of organic matter. Investigators of high ability have been deeply interested in the numerous processes which are continuously involved. Many conflicting theories have resulted from these investigations. The present situation is remindful of the confusion that, in a past day, arose around a structure which was being erected by the descendants of Noah, in the land of Shinar.

A complete history of man's ideas concerning the nature and the function of chlorophyll would prove highly interesting, but we have space only for a brief consideration of the most important recent advances in our knowledge. Regarding the history of our knowledge concerning the function of chlorophyll, it is sufficient to say that prevailing ideas and conceptions concerning its nature were largely worked out before we knew anything at all regarding the chemical nature of the pigments involved. We had the problem solved before we even knew the fundamentals. In other words, we had the problem solved years before we knew the complete nature of the problem which was ours for solution. New ideas which were developed were made to fit into an attempted explanation rather than made to assist in explaining a complicated process which was difficult to understand. Thus, rather than serving to clarify the picture, our ideas only clouded that which

we sought to understand. So we must become again as little children and seek to understand the glories of the heavens and the wonders of our earth and their interrelationships.

Chemists have been leading the way by rendering valued assistance in untying the Gordian knot which has been so skilfully tied by nature in such a complicated manner. Exactly one hundred years ago, this year, Berzelius first sought to understand the chemical nature of chlorophyll. The problem was beyond the available methods and technique of his day. While his conclusions regarding the nature of chlorophyll were largely different from those of our time, his objective was correct.

Forty-one years later Hoppe-Seyler, using improved methods, made an attempt to isolate chlorophyll. His experiments likewise were not successful. Chemical workers then for many years made no further attempt to isolate the green pigment, for the task appeared hopeless. Chlorophyll was discovered to be easily altered, it was chemically indifferent and extremely soluble, especially when mixed with so many impurities. These difficulties made the isolation of the pure pigment appear insurmountable.

By carefully studying the published works on chlorophyll and with the aid of many new experiments, Willstatter[1] largely deduced the characteristics of its constitution from a consideration of its derivatives that were formed from its reaction with acids and alkalies. So perfect were his deductions that when the preparation of the natural pigment was finally accomplished in a pure state, nothing new was learned from its analysis. Pure chlorophyll was found to have six important characteristics, and all these were fully known before the pure pigment was isolated in 1911.

We have here a deductive method which was used to accomplish that which could be accomplished in no other way. Finally, because of the knowledge gained, the impossible became possible and pure chlorophyll was isolated. Preparations which were made, using new methods, fulfilled the six characteristics laid down by Willstatter. His analytical data have been supplemented and improved by means of new preparations.

Using Willstatter's deductive methods and making use of published information which bears on the chlorophyll problem, we should be able to figure out some important characteristics of the function of chlorophyll—a problem which because of its intangibleness is difficult of solution.

Not a single investigator will question the statement that chlorophyll has something to do with energy and light and with the production of our foodstuffs. These are our gospel truths. The health-giving properties of chlorophyll and the substances which accompany it are also being established. Chlorophyll and its accompanying substances are intimately associated with health and with life.

Only eleven years ago, both Conant and Fischer began chemical investigations on chlorophyll. These investigators have established the complex chemical nature of the chlorophyll molecule. The chemical composition of chlorophyll, as given by Willstatter, has been wholly substantiated and the finer details of the molecule have been worked out. The Küster structure for the arrangement of the pyrrole nuclei has been approved.

These workers have shown further how closely the chemical make-up of chlorophyll approaches that of hemin. As work has progressed, chemical investigations have shown that the chemical make-up of these two prominent substances is almost identical. Both are complex porphyrin compounds. Their work has been such that they have made porphyrin chemistry a most vital part of all living things, plants and animals. Porphyrin chem-

[1] Willstatter and Stoll, "Investigations on Chlorophyll." Trans. by Schertz and Merz. 385 pp. 1928.

istry is such an inviting subject that Fischer[2] in his laboratory is carrying on investigations as to the nature of the porphyrin complexes which are present in the lower plants and in bacteria.

The chemical nature of these pigments is such that Emma M. Dietz[3] has seen fit to make the following statement: "In the slow development of the chemistry of these two pigments, it has been an increasing source of wonder to chemists to find that two substances of such widely different origin and function are yet so remarkably similar in structure."

Chemical investigations completed since 1900 have revealed the close chemical relationship of chlorophyll and of hemin; they have established porphyrin complexes as a vital part of living processes; and they have caused chemists to wonder about the origin, the structure and the function of these remarkably similar substances. The chemist has given to us the finer details of the structure of the hemin and the chlorophyll molecules, and he has further revealed to us their wide distribution in nature. In fact, many hundreds of complex porphyrin compounds have been prepared in the laboratory, but not one of these is to be found occurring naturally in plant or in animal life. This fact suggests to us that something vitally different is going on in the cell from that which is being accomplished in our test-tubes. Our chemical laboratories have proven that chlorophyll and hemin are built on the same structural plan, but they have offered little as to an explanation of the life processes which involves these pigments. It is possible that some of our ideas of chemistry have been actually blinding us as to what is going on in living cells. Studies in this field should reveal some of the characteristics of the function of chlorophyll. The facts are, we know a lot about what the chemist can make out of chlorophyll, but our question is, "What does nature make using chlorophyll?" Chlorophyll, hemin, powerful catalysts as catalase, peroxidase and cytochrome C are all naturally occurring porphyrin complexes, and a study of them should assist us in a solution of our problem. Traces of porphyrins are widely distributed in nature, but as yet their biological function is unknown. The rôle of this type of molecule in natural processes needs investigation. Chemical investigations on chlorophyll and on hemin have not answered the question how plants take up carbon dioxide and form our foodstuffs, but they have shown us that plants and animals have something fundamentally the same in their make-up. Perhaps one of the characteristic functions of chlorophyll is also a characteristic function of hemin.

Recent studies on chlorophyll enable us to further observe that even a more close relationship exists between hemin and chlorophyll. Man long has known that hemin is only part of a large functioning molecule. Four molecules of the red brown pigment, heme, are attached to a colorless protein (globin), and the complex is known as hemoglobin. In the case of chlorophyll, the picture is not so well defined, for very recent research has revealed a similar state or condition for chlorophyll. Smith[4] has prepared aqueous solutions of chlorophyll which show characteristic protein properties. These pigmented solutions resemble the pigment as it exists in the leaf. Carotenoids are believed to be associated with this chlorophyll complex. This chlorophyll-protein complex has been given the name of "Phyllochlorin," which is analogous to hemoglobin. Ten years ago, Lubimenko[5] has stated that natural chlorophyll is not a simple mixture of green and yellow pigments, as is generally believed, but it is a colorless albuminoid,

[2] Hans Fischer, *Chem. Rev.*, 20: 41–68, 1937.

[3] Emma M. Dietz, *Jour. Chem. Ed.*, May, 1935. Pp. 208–216.

[4] Emil Smith, *Science*, 88: 170, 1938.

[5] Lubimenko, *Rev. Gen. Bot.*, 40: 415–17 and 486–512, 1928; also, *Chemical Abstracts*, 22: 3906.

giving an aqueous colloidal solution which breaks up on coagulation to form colorless protein and the pigments. Thus daily, the picture for chlorophyll is becoming more like unto that for hemin. Both pigments in their natural state are part of a protein complex. Perhaps, after all, their functions may not be as dissimilar as we have been leading ourselves to believe.

There is a growing awareness that something besides the chloroplast pigments is deeply concerned in the production of our foodstuffs. Unsupported theories have existed merely because there has been no other plausible explanation. Investigators[6] now are studying organic compounds with a view to better understanding the metabolic processes which are fundamentally concerned with the primary stages of carbon dioxide absorption.

The matter of carbon dioxide absorption is an open question. It might be appropriate to open again the question of oxygen in its relation to hemoglobin. Only two years ago an investigator[7] has sought to know why nature chose a molecule with a molecular weight of 68 thousand to transport oxygen with a molecular weight of 32. He also has asked why nature has chosen a colored pigment for this purpose. These questions being asked regarding hemoglobin are in perfect harmony with doubts we all hold concerning our own past ideas regarding chlorophyll. Perhaps a solution of questions regarding one of these pigments will aid in solving questions regarding the other. Questions can not be raised regarding chlorophyll without at the same time raising questions regarding the function of hemoglobin.

Returning again to our gospel truths, it is known with certainty that hemoglobin and phyllochlorin are intimately associated with light. Both animals and plants respond wonderfully well to light factors. Both need sunshine and both use sunshine. These are facts, but the how and the why have never been very satisfactorily explained.

The characteristics of the function of chlorophyll, which I have named, point to but one conclusion, namely: that chlorophyll is a pigment which nature has given to plants as a means of absorbing energy in the form of light. In other words, when chlorophyll was given to our earth, living processes could then proceed at a tremendously accelerated rate. Undoubtedly, in our present scientific literature, all the characteristics of the function of chlorophyll—and of hemin also—are to be found. The difficulty which confronts us is our own inability to recognize them. If only for a second we could be permitted to get a glimpse of the natural function of chlorophyll, then we could turn the pages of our recorded scientific endeavors and rapidly assemble the attributes of the function of this compound, as it actually exists in nature, rather than as it exists in the minds of a single created species.

Since we are not permitted even a glimpse of a second, then let us humbly presume that we know the function of chlorophyll, and assemble some of its attributes. By assembling what is even now in the literature, it is possible for us to conceive of chlorophyll as being nature's means of converting energy to matter. Undoubtedly chlorophyll has no monopoly on this function, for all chemical substances are known to absorb rays from one portion of the spectrum or from another. Plants and animals, then, which are large absorbers of portions of the spectrum become nature's prime energy converters.

In nature's scheme, then, plants and animals can be placed in a single category, while man for convenience has placed 250,000 species in one class and

[6] Kenneth Thimann, *Science*, 88: 506, 1938.
[7] *Science News Letter*, p. 70, Aug. 1, 1936.

950,000 in the other. All these 1,250,000 species are coworkers with nature in accomplishing her end—that of making earth substance from energy.

If nature is producing earth substance from energy, using living things as transformers, then we can look forward to the realization of the alchemist's dream, in the leaves of plants, where these forces are most active.

Under this scheme of things, creation then is continuous and eternal, for that which gives and sustains life is continuously flowing to our earth and to all living things. Creation then is greatest where life is most lived—where the species population is most dense. The stuff of which we have been made is here now and we are a part of it, but the essence of the stuff of which we are being made and of which our children and our children's children will be made is yet to come. Man is something far more than mere dust, for he is continually partaking of the spirit of creation.

In conclusion, let me say that in interpreting chlorophyll as I do, I am simply attempting to solve problems which are most intimately associated with my own field in which I have studied for more than twenty years.

Problems which are fundamental can be solved when and only when we dare to think differently than men have thought heretofore, and the more fundamental the problem the more we will have to reshape our own thought processes. Nature's processes are going on everywhere in and about us, the same as they have been for more than a billion years. These we can not change, but we can change our conception of the processes involved, and that is the function of science and of scientific men. When we have changed our fundamental conceptions of the processes involved we have then placed ourselves in a position where we can reshape the future of all nations and of all men. It is the truths of life that we seek and when these are known, upon this structure, we can begin to build a more ideal civilization.

A COMPASS FOR MANKIND

By D. S. BURCH
WASHINGTON, D. C.

WITHIN the United States there is a secondary "population" much greater than the number of people whom we commonly consider to be the principal inhabitants of this country. The secondary population has no accumulation of serious problems. There is no material unemployment. There is no crime worthy of mention. The health status of this secondary population is good—and constantly improving. Each succeeding generation is better physically than the preceding one.

This is not a fanciful social order. It is real and tangible. And in it may be found the counterpart of scores of human problems with keys to the proper answers. As you may have surmised, this secondary population is the nation's vast aggregation of domestic animals.

KNOWLEDGE FROM JUNGLE BEASTS

From primitive times man has learned much to his advantage from animal life. He followed the trails of wild creatures to find water holes and food in the jungle. At Versailles early in the study of aeronautics, man sent a sheep, a duck and a cock aloft in a balloon as the first aerial travelers—and not until he got them back unharmed did he himself ascend in search of the secrets of the upper air. In more recent times man has gained much of his medical knowledge from the reactions of

animals. And when in need of adrenalin, pepsin or other glandular extract, he has no compunctions about taking his supply from an animal source—not to mention many articles of food and clothing also. None of this experience has made man any the less human, but on the contrary has been a vital power for his comfort and welfare. And what now can be more natural or sensible than to study animal life from social and economic angles to glean from it new and profitable applications.

First, it is noteworthy that the United States Government, through its Bureau of the Census, thinks enough of the nation's cattle, hogs and sheep to count them every five years, whereas it gives the human population a thorough count only every ten years. The last animal census, in 1935, showed the total number of live stock and fowls to be well over half a billion head. The welfare of this vast animal aggregation is nominally in charge of a cabinet member, the Secretary of Agriculture. But by act of Congress back in 1884, which created the Bureau of Animal Industry, most of the federal supervision of farm animals was assigned to that unit. There is cooperation with other branches of the federal establishment and also with states, but the chief responsibility has gravitated to the bureau mentioned. Its chief, Dr. John R. Mohler, holds high command over this great animal empire and has done so continuously since 1917.

Race Improvement

In any effective effort to bring about real and lasting betterment of the human race, we must not be squeamish about admitting that man is an animal—a highly intellectual one, a refined one, but still an animal. And the operation of heredity in the human family parallels that of the lower animate species. But while spokesmen for human welfare have been debating the sterilization of unfit parents and birth control, those in charge of our animal world have long endorsed the soundness of these policies and carried them out on a vast scale.

In a sylvan setting on a government farm near Middlebury, Vt., is a bronze statue in honor of distinguished parenthood. It is not of a human being, but of a horse, Justin Morgan, the progenitor of the famous Morgan breed. I have not been able to learn of any comparable statue erected to man or woman in recognition of contributions to race improvement, biologically speaking. In determining number of offspring, those in charge of animal life produce as many as they can properly care for under current and prospective conditions. The Federal Government and the States freely distribute information on what the needs are likely to be for the different classes of animals.

Meanwhile the world's uncontrolled human population is making a net gain of nearly 100,000 persons a day, of which the United States contributes about 3,700—enough to establish a small town every day. The question naturally arises whether it is wise to outlaw birth-control knowledge and continue to increase human population in a nation and world where competition for existence is already fierce. Or are not the live-stock folks acting more rationally in controlling both numbers and quality?

Eugenics societies and some religious groups merit commendation for their zeal in genealogical studies. But even these progressive organizations have been outmarched by groups engaged in the improvement of the lower animals. Live-stock breeding associations have set up official records of performance for measuring attainments, such as speed in horses, milk yields in cattle and egg production of fowls. The worth of an animal as a parent is judged largely by the quality of all its offspring—not just a few of the best. The record work is intricate,

but it gives the desired results. I asked a nationally known genealogist why, if all this was worth while for the lower animals, it wouldn't be much more so for people. He agreed that it would, but added, "We just don't do it."

Merely as one example of how comparable human records would be useful, consider the advantage of knowing positively the racial history of a prospective mate. Such a system would tend to prevent the heartache of Caucasian mothers who have married presumably white suitors, but have borne dark-skinned babies with other unmistakable negroid characteristics.

Sound judgment, of course, denies any direct transplanting of method, but the animal world provides answers to several human problems. Birth control is sound in principle. The best measure of parents is not so much their ancestors but the kind of children they have. Our genealogies can be made to indicate the prospective physical traits, talents and temperament of our children, when the records are complete in such matters as stature, longevity, occupation, avocations, and the like.

Better Health

The same basic knowledge regarding anatomy, medicine and means of preventing disease serves man and animals alike. But there are striking differences in the manner some of this knowledge is applied. A tuberculous person may board a train in New York City and travel across the continent in close association with fellow passengers. He may chat with them, play cards with them and eat with them. He would resent interference with his independence. But if that person attempted to ship a cow in a stock car, he would not find it so easy. He would have to show that the cow had passed an official tuberculin test or was from a recognized accredited area. Under permit, diseased cattle may be shipped for slaughter, but in that case Uncle Sam puts a placard on the car, ordering its cleaning and disinfecting when unloaded, and there is an inspector on hand to supervise the job. When live stock go traveling, especially across state lines, Uncle Sam is on the job with John Law to back him up.

Most major live-stock maladies and scores of lesser ones have yielded to veterinary attack. Briefly, the United States is now widely regarded as the safest country in the world for the raising of live stock. The procedure for eradicating certain diseases is noteworthy. When an official veterinarian goes on to a man's farm or ranch to test cattle for tuberculosis, he does not present a bill for the work. On the contrary, he arranges to pay a fair indemnity for any cattle found to be diseased. The owner also gets whatever salvage the diseased cattle will bring. In other words the owner gets paid for getting rid of such animals, and the testing is free.

But the procedure is not so topsy-turvy from a medical standpoint as this description may sound. The officials who direct this work are interested primarily in serious infectious diseases. These are the ones that spread and spread, causing economic loss and often endangering human lives as well. So the officials have concentrated on the most dangerous diseases and have left the remaining field largely in the hands of private practitioners. The government also maintains rigid quarantines against infection from abroad, and these apply to many animal products as well as to the animals themselves.

This outline of official veterinary service is offered in answer to the question, "Is state or socialized medicine sound and proper?" There has been much discussion of this question, but the correct answer is clear. Leaders in the medical profession, with becoming grace, have often paid tribute to the

remarkable success of "state medicine" for animals and the resulting public benefits. By proper adaptation, what is good for a lower animal would logically be good for a higher one. In fact, man already has some state medicine indirectly because improved live-stock health has reduced several human ills and the death rate associated with such ills. In the light of this experience, state or socialized medicine is sound and proper when limited to those diseases that endanger society.

Law and Order

In seeking clews from the live-stock world on best methods of curbing crime and enforcing laws, we find many striking analogies. For scores of years stockowners have maintained brands and other marks of identification. On this basis, the practice of human finger-printing is eminently sound and deserves much wider application among our citizens. Typical animal "criminals" are the sheep-killing dog, unruly bull and predatory wild animals, and let us not overlook also the ordinary rat. Live-stock officials and owners tolerate no leniency in dealing with such enemies. They likewise practice scientific methods of prevention and control. They breed cattle without horns. And the domestic hog, though descended from the fierce wild boar, has been bred into a relatively peaceful animal. The principle of disarming the criminal element is thus obviously sound.

The practice of offering bounties for the capture of wild predators has given way gradually to the better system of an aggressive hunt. Bounties and rewards thus seem to merit but a minor place in law enforcement. The skilled stockman limits the kind and amount of stimulating feeds he gives to animals of nervous temperament. He eradicates or keeps his stock away from toxic plants. These procedures point to the soundness of supervision over too liberal use of drugs and narcotics by the human family.

The type of federal and state laws that apply to live-stock affairs is also noteworthy. These laws deal essentially with objectives to be reached, together with specified penalties for violation. They likewise designate responsibility for their enforcement and outline the means. Yet they provide, also, discretion and latitude of administration by empowering designated officials to make rules and regulations.

This type of law has been eminently successful. As need arises, new provisions are added to meet new developments and old provisions are dropped as they become obsolete. All changes, of course, are well within the original basic authority, and interested persons receive proper notice. Those subject to the laws always have redress in the courts if they wish to challenge a new order or ruling. In brief the live-stock laws are kept up to date, a condition which, in itself, commands respect. A further basis for respect is their impersonal enforcement. One federal law, for instance, provides that animals brought here from specified foreign countries must undergo veterinary observation in quarantine. This law applied to Kedron, the war charger of General Pershing, on returning to the United States at the close of the world war. Acclaimed by the nation, the general led his victorious legions in colorful parade from the Capitol to the White House—but he rode another horse. Kedron was in veterinary quarantine.

The penalties provided by the laws which govern this inner live-stock democracy are high enough to command respect and compliance. A reckless driver or speeder on a city street, endangering human life, feels aggrieved if fined $5, $10 or $25. I recently spent two days in court in Washington, D. C., as witness for a friend whom I had seen run down by a truck with bad brakes. Counsel for the defense brought forward an array of excuses, and the truck driver finally received a fine of $25. But if, instead of

striking a human being with a truck, this man had failed to unload hogs, en route to market, for feed, water and rest, he likely would have paid a fine of $100, the minimum penalty for mistreating live stock under the 28-hour law. He would have faced a similar fine for driving ticky or tuberculous cattle across a state line.

Should an offender feel gifted in inducing friends at court to fix traffic tickets or dismiss charges against him, he will wisely omit such tactics in live-stock jurisprudence. Especially is he cautioned not to try his persuasive powers, accompanied with a gift, on a federal veterinarian engaged in meat inspection. To give or offer money or anything of value to an inspector with intent to influence him in the discharge of his duty is a felony. The least penalty, on conviction, is a fine of $5,000 and a year's imprisonment.

Practical Labor Applications

To extend experience with animals to the intricate problems of labor relationships may seem fantastic. But let us consider several ranging from immigration to child labor. The animal population, like the human, originated largely in other countries. Choice breeding animals are welcome from abroad without limit. In fact, the government itself has sought out high-quality animals from remote parts of the world. But unhealthy or otherwise unfit animals find no such welcome. Thus animal immigration is highly selective.

In the field of racial problems, the separation of different classes and breeds of animals has long been a live-stock custom. Each has its separate quarters on farms, even though several kinds may run together on occasions. Different biological species, in brief, do not mix well from an economic or management standpoint. The inference is: In general keep races of workers separate. They get along better with their own kind.

Among the animal "workers," compensation is in terms of feed, housing and care. The better bred and more productive receive preferential treatment in these respects. The reasons are economic, not sentimental. The animals that earn more for their owner receive more from him. Applied to human affairs, the deduction is that efficiency and volume of production are the proper bases for wages. And since even an inferior specimen, that is good enough to keep, merits at least a maintenance ration, and commonly receives more, the principle of minimum wage is sound. In the production of most animal products the curve of efficiency roughly approaches that of an arch, rising to its greatest height in the prime of life and then declining. On the basis of this analogy, the correct principle of wages for human physical work is advancement from the period of youthful effort to that of greatest output, followed by some curtailment in the worker's declining years. The human custom of retaining aged persons in positions that make too heavy drains on their constitutions is contrary to sound biological practice. The principle of adequate vacations, with pay, is supported by analogies in the animal world, ample rest periods being essential for the best productive effort.

There is practically no unemployment in our animal economy, owing to foresight in regulating the number of workers. Once in three years the Bureau of Animal Industry surveys the horse and mule situation and points out the prospective needs several years hence. The data include number, ages and quality of breeding stock and of young animals approaching working age. This service has been useful in adjusting the supply to the probable requirements.

There is a virtual taboo in live-stock circles on the use of immature animals for steady work. That would be injurious to the animals and unsound from a practical standpoint, regardless of the

humanitarian side. On this basis child labor is unsound, and measures for preventing such labor have ample support from the live-stock world.

Adequate and sanitary housing has a close parallel in both human and live-stock fields. Merely on the grounds of economic productiveness, good housing is sound. Witness the many farms on which the barns have surpassed the human dwellings at least until returns from farm operations were sufficient to finance better homes. There is abundant live-stock experience to support slum-clearance programs.

Basis for Skilled Statesmanship

Experience from the animal world, of course, has scores of other applications to human affairs. Veterinary and other scientific gatherings suggest means of improving legislative procedures. Before such technical groups there is an orderly presentation of evidence, but little debate. Action on the evidence is commonly unanimous or nearly so. The facts speak for themselves. Oratory, whether laudatory or acrimonious, has slight influence on the discerning scientific mind, and is regarded largely as an entertainment feature. Hence in legislative debates on questions of public welfare—which parallel those of animal welfare—extensive argument indicates an absence of sufficient evidence. Decision had better be deferred until more facts are at hand. The same is true of close votes involving only a slight majority. New legislation which lacks support by a large majority may be looked at askance, possibly in the light of a temporary expedient rather than as sound statesmanship.

Although perhaps a coincidence, it is noteworthy that many of this nation's best chief executives and congressional leaders have had a background of farm experience, giving them an intimate understanding of natural laws. Quite conceivably this rural knowledge may have added wisdom to their judgment in the administration of public affairs.

Tradition, of course, is strong, having too powerful a grasp on thought and conduct to permit early departure from present habits.

Yet when one must plan a new course or make a difficult decision, he may wisely scan the efficient conduct of the animal world for sound precedent and safe guidance. Of course, there is the stereotyped challenge, "But you can't treat human beings like animals." True—but why not treat them at least as well?

BOOKS ON SCIENCE FOR LAYMEN

WEATHER IN WORDS AND PICTURES[1]

THIS is a republication by a new firm, but with none of the many needed changes of text. It is such a beautiful piece of book-making, however, that it deserves to be adequately revised, with the replacement of half its 59 illustrations by others more closely and obviously related to the subject-matter. Its errors are far too numerous to discuss in detail, so only a few of the more important will be cited.

Long ago some animist explained atmospheric convection by asserting that warm air rises (presumably voluntarily as a cat climbs a tree) and cold air comes in to take its place and thereby prevents the formation, or maintenance, at least, of a vacuum—voluntarily, presumably, and out of the kindness of its heart! Ever since that unhappy day nearly all writers, including many who, like Mr. Pickwell, certainly know better, persist in perpetuating this absurd error, instead of explaining convection correctly, intelligibly and in even simpler terms.

On page 19 it is erroneously stated that the blue of the sky is caused by dust particles. And on the next page we find the absurd statement (not original with Mr. Pickwell, however) that if there were no dust particles the sky would be black. The paragraph that contains this last error contains also several others.

The exceedingly misleading idea that the air holds water (as does a sponge, perhaps) is repeated over and over, whereas the air is inconsequential in this particular. This error, too, is persistently repeated by many other writers. Some even state the matter correctly in one sentence and wrong in the next.

Mr. Pickwell says (page 40), as do many others, that the air is cooled mainly by being pushed up into colder regions aloft, not by the loss of heat through the work of expansion against the surrounding pressure.

The explanation of "black" lightning, page 96, a purely photographic effect, is quite the worst I have seen. And there are many other slips. The text needs a thorough revision.

On page 145 the oft-quoted statement, "Everybody complains about the weather, but nobody does anything about it," is, as usual, credited to Mark Twain, and not, as it should be, to Charles Dudley Warner.

But for all that, the two-page picture of a tornado cloud is worth the price of the book.

W. J. H.

[1] "Weather." By Gayle Pickwell. Illustrated. ix + 170 pp. (quarto). $3.00. McGraw-Hill Book Company.

PRACTICAL SCIENCE IN THE HOME[1]

ALTHOUGH this book is designed as a college text for courses in home economics, it has in it so much of interest and importance for both the inside and the outside of the house that the head of every household should find it a valuable handbook. In our modern mechanized life, whether we live in the city or in the country, we are surrounded by the products of science which often require expert attention. To be able to service them is a great saving in time and money; to understand how to do it gives one the satisfaction of being the master. The numerous problems in this book would be to many persons much more entertaining than any cross-word puzzle.

There are in this book five general divisions—"Mechanics," "Heat," "Electricity," "Sound" and "Light." After explaining in each of them in elementary terms the basic principles of the subject, innumerable applications in the home are taken up from the practical point of view. For example, under "Mechanics" there are illustrations from such familiar

[1] *Household Physics.* By Madalyn Avery. xv + 439 pp. and 378 cuts. $3.50. The Macmillan Company.

things as the pump handle, nut cracker, wheelbarrow, human arm, steering wheel, clothes wringer, gears, jack, window sash, sewing machine, including lock stitch and tension, hydraulic brake, barometer, pressure gauge, suction pump, force pump, vacuum cleaner, gas regulator, gas meter, gas burner, water supply, water meter, bathroom plumbing, including faucets and valves, sewage pipe, flush valve, flush tank and septic tank. The reader will be surprised at the small number of simple principles on which the mechanical operation of all these things depends.

Under "Heat," to mention a few things, we find the thermometer, thermostat, oven temperature regulator, steam cooking utensil, pressure cooker, insulation, vacuum bottle, refrigerator, stove, furnace, hot-water boiler, air-conditioning unit and weather. Again the basic principles are few and the practical application to affairs of every-day life in the home are many.

In the section on "Electricity" there are found not only the almost numberless appliances using motors, but also heating devices of all kinds from curlers to hot-water heaters and ranges; there are also electric lamps, electric plating and electric cleaning of silver. Then follow matters of electric wiring, meters, fuses, transformers, batteries, household generating units and lightning.

Under "Sound" we find the human ear, noise, musical instrument, microphone, telephone receiver, loud speaker and related things. Under "Light" not only the human eye and illumination, but also optical instruments of various kinds and even x-rays and their uses. This partial list of subjects treated gives a general idea of the scope of the book. It is a pleasure to express the opinion that the discussions in it are clear and scientifically sound and that the illustrations are excellent. Probably even more important than the practical usefulness of the book is the scientific attitude toward the affairs of every-day life that it will stimulate. F. R. M.

SOME FACTS OF SCIENCE OVERSIMPLIFIED[1]

In an attempt to give a reasonably clear notion of the nature of the atom, a scientific writer sometimes likens its structures to that of a miniature solar system. This analogy reveals, to the lay mind, at least, what is akin to a sense impression of this small unit of matter. So every careful investigator tries to use some effective device by which to present his knowledge to others.

It would seem that under so good a popular title as "The Magic Wand of Science" an author should be able to fire the imagination of his reader and thus the better to acquaint him with many significant facts. Such a result could be accomplished by careful selection of material and by a sufficiently complete setting forth of fundamental data to enable the reader both to comprehend the significance of the things discussed and especially to glimpse something of the scientific processes by which these things are created and utilized. In these matters the author of the book in question seems to have failed in great measure. The facts presented are generally known by all who may read the book; the presentation is so commonplace that the reader gets little more than the names of the items presented together with a rather broad statement of their significance. The account is much like a newspaper recitation of certain inventions and discoveries that are already known to the average high-school boy and to most men on the street. It hardly needs a book with an apt title to reveal that the things enumerated exist and that the names of certain men are connected with them.

J. E. Thornton

Brookings Institution,
Washington, D. C.

NOT MUCH ABOUT PETROLEUM[1]

The table of contents of this little book

[1] *The Magic Wand of Science.* By Eugene W. Nelson. Illustrated. 212 pages. $2.00. E. P. Dutton and Company.

[1] *About Petroleum.* By J. G. Crowther. Illustrated. xiv + 181 pp., 14 plates. $2.25. Oxford University Press.

lists chapter topics covering essentially all phases of the petroleum industry. It is obvious that few if any individuals could claim to be sufficiently well informed to write authoritatively or to examine critically more than a few of them. The present reviewer feels that his competency for a critical examination of the subjects included is restricted to those chapters concerned with the origin, production, exploration and drilling for oil. His reactions to those portions are so unfavorable that, regardless of the merit of the other sections, it is felt that the book is not suitable for use for the avowed purpose of providing a "simple introduction to 'The Science of Petroleum.'"

Numerous instances of misplaced emphasis and of statements not in harmony with the theories generally accepted in the United States regarding the origin and accumulation of petroleum occur in the first and other chapters.

It is difficult to select specific inaccuracies without implying that the ones mentioned are the most important; they can not all be included, for the list would be too long. It is to be regretted, moreover, that the statistics presented in the book in general are not for any period more recent than 1936, whereas reasonably accurate statistics for the petroleum industry for 1937 have been available since February of 1938. It is unfortunate that portions of a book of this scope which might have provided a useful general survey of the various phases of an important industry contain so many statements which seem to be at variance with theories generally accepted in this country.

GAIL F. MOULTON

BIG FLEAS HAVE LITTLE FLEAS[1]

SHOULD scientists try to give to the layman the results of investigations in their own fields? This is a problem which has caused much discussion and for which there can be no one answer which will apply to all cases. Dr. Robert Hegner has given his personal answer to this question in the book "Big Fleas have Little Fleas." Not only has he written a book which can be understood by any layman who is willing to read, but he uses clever line drawings and catchy rhymes to drive home his points. The study of the Protozoa is a very new field and the author has actually lived through many of the phases about which he tells. This makes it possible for him not only to give information about the subject, but what is just as important, to tell how such information has been obtained.

As the title indicates, the book has as its main subject the story of parasitic Protozoa and stresses particularly those which are of importance to man, although the free-living forms are by no means neglected. Sarcodina, Mastigophora and Infusoria are introduced so that their parasitic members as well as those of the Sporozoa can be passed in review. Of the parasites, a few of those which inhabit lower forms of animals are discussed so that the problems of commensalism, symbiosis and parasiticism can be made clear. Most of the book deals with important human types, such as the organisms causing amoebic dysentery, malaria and African sleeping sickness.

Every human being is directly or indirectly affected by the Protozoa, but very few realize how important their place in nature is. Those who yearn for the good old days have no conception of the changes which our knowledge of these simple organisms has produced on the human race. Reading this book will open their eyes to the problems involved and help them understand the ways in which this knowledge has been obtained, and incidentally show them the tremendous number of problems which still remains to be solved.

D. B. YOUNG

[1] *Who's Who among the Protozoa.* By Robert Hegner. Illustrated. 285 pp. $3.00. Williams and Wilkins Company.

THE PROGRESS OF SCIENCE

MEETING OF THE AUSTRALIAN AND NEW ZEALAND ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE

THE arrival in Canberra (pronounced Canbrough!), the capital of the commonwealth of Australia, at five o'clock on the evening of January tenth was the welcome termination of a hot, dusty, steaming, 500-mile drive north from Melbourne through a smoke-drenched country which made it impossible to see the surrounding hills and which choked one's throat and made one's eyes red and uncomfortable. The temperature as we went through Albury—about half way to Canberra—was 107°, and every one was looking limp and miserable. However, after a cool shower (the cold water was actually warmish!) and a change, the world seemed cooler and less grimy.

Many of the delegates had arrived previously at the Hotel Canberra, and the first evening was spent meeting other overseas delegates and the officers of the Australian and New Zealand Association for the Advancement of Science. The official guests from England were Sir John Fleet, Sir John Russell, Professor F. T. Brooks, Professor N. V. Sidgwick and Mr. H. G. Wells. Professor R. H. Carr, of Purdue University, and I represented the American Association for the Advancement of Science. We all received most cordial and generous hospitality.

The meeting proper began on Wednesday, the eleventh of January. The American delegates were invited to attend the general council meeting, which was managed in a very business-like manner. At noon the over-seas delegates were entertained at luncheon by the president, Professor Ernest Scott and Mrs. Scott; at 2:30 P.M. the Minister of the Interior, Mr. Mac Ewan, and Mrs. Mac Ewan gave a reception for the over-seas delegates and at four o'clock the Ministers of State gave a garden party at Parliament House.

After dinner that evening there was a formal meeting, at which the presidential address was delivered, Professor Scott's topic being "The History of Australian Science." His subject was particularly timely, for the Canberra meeting closed fifty years of accomplishment of the Australian and New Zealand Association. This gala opening was attended by Their Excellencies, the Governor-General of Australia Lord Gowrie and Lady Gowrie, who entertained the over-seas delegates at luncheon on Thursday at Yarralumla, Government House. Government House is a charming place, set in beautiful gardens. Work has already been started on improving Yarralumla for the advent of the Duke and Duchess of Kent; the Duke of Kent is to be the next Governor-General of Australia.

Yarralumla, as it was in January, is the sort of place which belongs to Canberra, that strange fascinating capital which is being built from outside in and which has room to spread in every direction. Selected after years of discussion, and, if history be true, heated argument as a compromise point not too much resented by either New South Wales (where Sydney is located) or Victoria (where Melbourne is situated), Canberra is really beautifully nestled among low hills presenting vistas toward distant mountains. Lying in a valley about 1,800 feet above sea-level, its summer weather is ordinarily quite comfortably cool, but this year it was *unusual* (the kind they have in Southern California when the weather is *bad*).

Construction of Canberra was begun after an international competition for a design for it was held, the first prize having been awarded to Walter Burley Griffin, of Chicago, who eventually went to Canberra to proceed with the

HOUSE OF PARLIAMENT

development of the plan. In his description of Canberra Mr. C. S. Daley, of the Department of the Interior, says: "The plan as originally drawn is regarded as being of marked distinction and originality. The author made skilful use of the excellent features presented by the site of effective planning. These consist of the scenic background of the Australian Alps; local mounts affording terminals to vistas and sites for future monuments; hills and spurs providing appropriate sites for public buildings and also terminals to main thoroughfares."

Canberra has lovely, wide streets, beautiful parkways, rich public gardens and a comfortable feeling of plenty of room. And in the midst of all this planned beauty, of all this striving for perfection and spaciousness, what do we find? We find three slum areas which should not exist and which are foci of delinquency, and that in a place which has been planned from the beginning!

On Thursday most of the presidential addresses were delivered and the scientific programs were under way. The Section on Anthropology was perhaps of greatest interest, one of the most fascinating illustrated lectures presented before it being that of Mr. E. W. P. Chinnery, one of the government anthropologists, who is director of District Services and Native Affairs of the Territory of New Guinea. He showed pictures of and described the exploration of an area in 1933 of 10,000 square miles, which is bordered on the north by the Bismarck range and on the south by a newly discovered range, three peaks of which are 13,000 feet in height. In 1934 Mr. Jack Hyde, sent by Sir Hubert Murray, pushed 100 miles northwest of the farthest point reached in 1933 and found a type of people similar to those encountered in the 1933 expedition.

This area contains some 200,000 people, who had never heard of the British Government or of any other government for that matter. Living at an altitude of 5,000 feet, there is apparently no link between them and the coast.

There are found in this region mortars

and pestles, stone birds and curious clay whistles. The clay whistles, found at Chimbu, are dried but not baked. The people play interesting games with humming tops, and they have very elaborate dances. Frequently one hears them yodling, but it is an original kind of yodling, not like that of the Swiss.

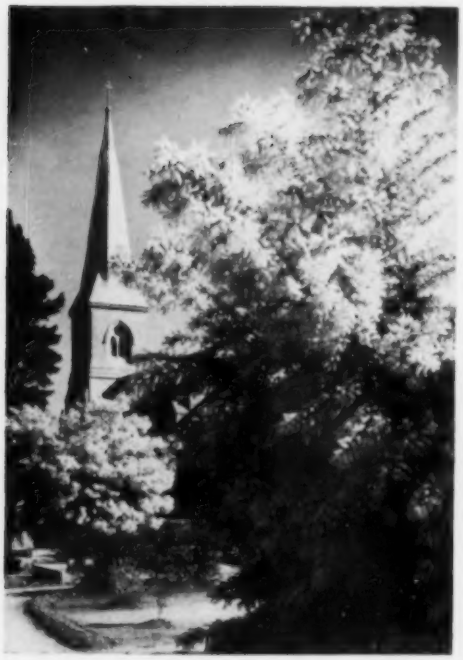
Miss Olive Pink presented a paper entitled "Bone-Pointing by Whites and its Past and Future Contribution to the Extermination of the Full-Bloods—the Aborigines of Australia," which gave a critical point of view of the treatment of the aborigine. Several illustrated papers on the art of the aborigine were presented, among the contributors being C. P. Mountford, R. H. Goddard and W. J. Enright. Australia is having a hard time keeping its anthropological treasures intact, for travelers here, as in all parts of the world, apparently are driven by some strange compulsion to carve their initials over these priceless records.

The Section on Medical Science and National Health had for its leading topic "National Fitness," which was the subject of the presidential address by Dr. E. Sydney Morris. Among the interesting papers in this section were ones on "Heart Size in Relation to Physical Exercise" and on "Physical Education as a Means to National Health," by Dr. Fritz Duras.

The Medical Section had joint discussions with Chemistry, Physiology and Pharmaceutical Science on the "Relationship between Chemical Constitution and Biological Activity," and another with Agriculture, Veterinary Science, Botany and Physiology on "Virus Diseases," and finally another with Physiology on "Animal Pigments."

In the Section of Education the presidential address by Mr. J. R. Darling, entitled "Growing up," was stimulating and thought provoking. Mr. Darling, head master of Geelong Grammar School, in Victoria, said experts could learn a lot from the ordinary man, and that it was a common sin of experts—and none were greater sinners than head masters—to

AUSTRALIAN INSTITUTE OF ANATOMY



THE OLD CHURCH OF ST. JOHN

COURT YARD OF THE HOUSE OF PARLIAMENT
WHERE THE SUPPER WAS SERVED AT PRESIDENT SCOTT'S RECEPTION.

brush aside the criticisms of their victims, concluding with the remark that the supreme object of education should be to help men and women toward constant, imperturbable yet active serenity of soul.

The Section on Agriculture and Forestry was faced with a real problem in the terrific bush fires (forest fires) which were raging in Australia during the first half of the associations' meetings. Australia has been reckless and ruthless in her destruction of trees and in her lack of conservation, and she has paid dearly for insufficient fire breaks and for permitting an accumulation of dried tinder-like material in her great forests.

Mr. Ambrose Pratt, an authority on the koala bear and the lyre bird, discussed the damage done to the koala bear in the recent fires. The sanctuary at Healesville, in Victoria, was threatened, and the little bears living in the sanctuary were billetted out in private families during the crises. Ordinarily it is an offence, punishable by a very heavy fine, to have one of these little bears kept in a private home. The koala is undoubtedly Australia's greatest native attraction, and because of its defencelessness and because of its very specialized diet, Australia had enacted legislation, designed to protect this delightful little creature from harm.

The great tragedy in all these science congresses is that very frequently papers that one wishes to hear in different sections all come at the same time. The writer was torn with indecision one day when five important papers in five sections all came at the same hour. Of course, we all went to hear H. G. Wells paint a gloomy picture of how the world is going to blazes, of how inadequate education is and how it can be saved through the rapid and zealous expansion and organization of the English-speaking community. Mr. Wells' two addresses caused a great deal of discussion and, as usual, he not only managed to get people to thinking, but got them articulate about it.

Sir George Simpson gave an excellent illustrated public address on the Ice Age.

This lecture came after a 50° drop in temperature, and after it a number of scientists went to see "Too Hot to Handle," which was playing in the town.

Social functions and delightful excursions added greatly to the pleasures of the Canberra meeting. The reception of the president was held in Parliament House, giving every one a chance to roam through the lovely building and to see the fine collection of historical exhibits. Supper was served in the beautiful and brilliantly lighted courtyard. The other very large function was a great garden party at Government House on a day when bush fires were raging and the air was hot and full of smoke.

ANITA M. MUHL, M.D.

AWARD OF THE FARADAY MEDAL TO DR. W. D. COOLIDGE

IN 1922 the Institution of Electrical Engineers, in London, established the Faraday Medal to be bestowed annually upon a scientist for some notable scientific or industrial achievement in electrical engineering, without restrictions as

DR. W. D. COOLIDGE

to nationality, country or membership in scientific societies.

It is appropriate that such a medal should be named after Faraday, who, by establishing the relationship between electric currents and magnetism about a hundred years ago, laid the foundations for all the remarkable and extraordinarily useful achievements in electrical engineering that have been the wonder of the world. The first Faraday medallist was Sir Oliver Heaviside, and the latest is Dr. William David Coolidge, director of the Research Laboratory of the General Electric Company. Among the others who have received the Faraday Medal are such great British scientists as Sir J. J. Thomson, Lord Rutherford, Sir Oliver Lodge, Sir William Bragg and Sir John Snell. Previous American recipients of the honor have been Dr. J. A. Fleming and Dr. Frank B. Jewett.

Dr. Coolidge is by no means a stranger to honors, having received the Rumford Medal of the Royal Society of London in 1914, the Howard N. Potts Medal of the Franklin Institute in 1926, the Louis Edward Levy Gold Medal in 1926, the Gold Medal of the American College of Radiology in 1927, the Hughes Medal of the Royal Society of London in 1927, the Edison Medal in 1927, the Washington Medal of the Western Society of Engineers in 1932 and the John Scott Award of the City of Philadelphia in 1937.

Medals and honors serve mostly in the eyes of the world as something on which to focus attention for a brief moment of hero worship. The things of abiding interest and consequence are the achievements they commemorate. It is much the same with scientists. Although they appreciate the approbation of their fellow men, especially of their scientific peers, their real satisfaction comes in exploring regions previously unknown and in discovering things that are permanent contributions to our understanding of the universe about us. Even if their discoveries give only intellectual pleasure they are satisfied; if they combine deep satisfactions to the mind with practical applications, as Dr. Coolidge's have done, they are delighted. In the presence of such satisfactions a medal is less important to the recipient than to those who read about it.

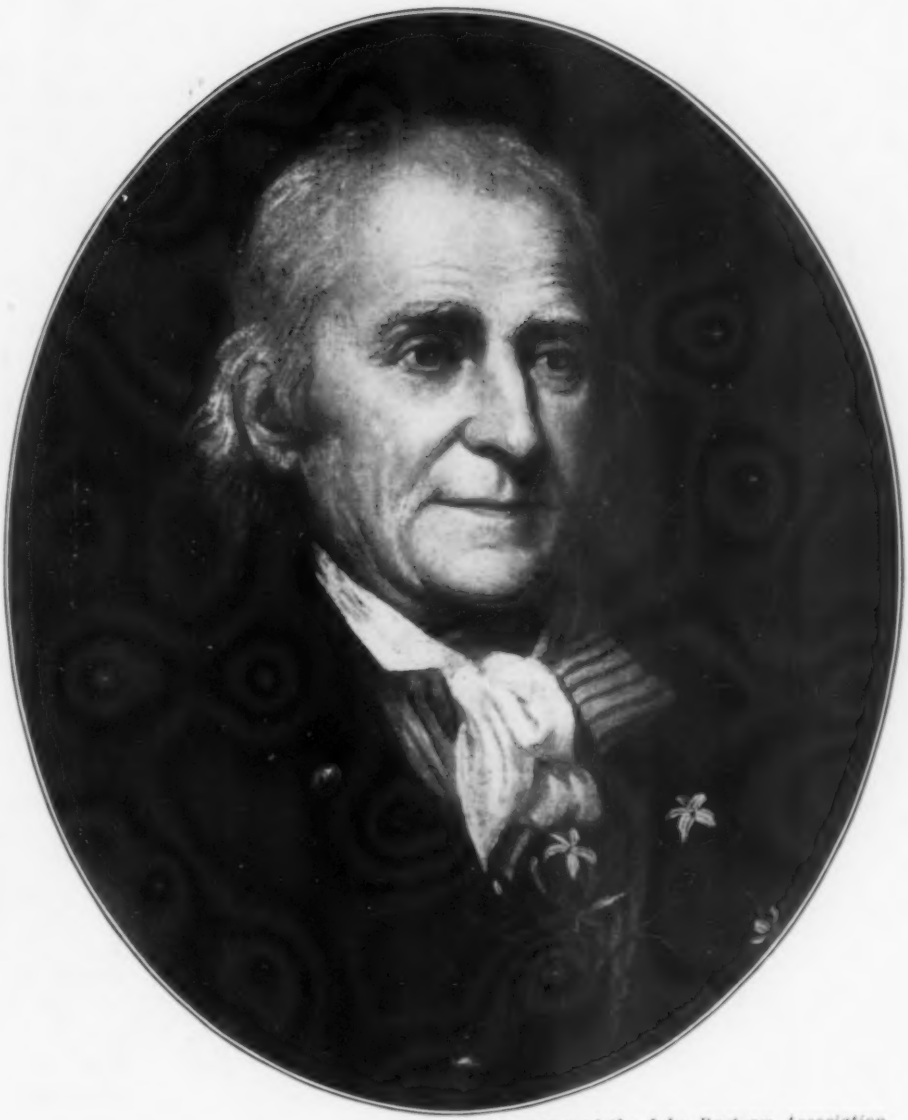
F. R. M.

WILLIAM BARTRAM'S BICENTENNIAL

THE steadily growing appreciation of William Bartram and his contributions to American literature and natural history is reflected in the celebrations this year of the two hundredth anniversary of his birth. On February 9 commemorative exercises were held at Rollins College, Winter Park, Fla., including addresses on several phases of Bartram's work and an exhibit of Bartram material.

At the same time a special exhibit of Bartramiana was opened at the Academy of Natural Sciences of Philadelphia; this includes books, drawings, letters, a diary and personal possessions of John and William Bartram, as well as portraits of themselves and some of their scientific friends and correspondents. Among the books is Alexander Wilson's own copy of Bartram's "Travels," recently presented by William Bacon Evans and Charles Evans. Another treasure in the academy's library is a copy of the tenth edition of Linnaeus's "Systema Naturae," presented by Dr. Thomas Hewston to William Bartram.

The John Bartram Association, of Philadelphia, has recently issued, under the authorship of Emily Read Cheston, a most informative little work on the father and the son, with an account of their old house and garden, still preserved on the banks of the Schuylkill in West Philadelphia. Last year the National Park Service issued a useful mimeographed sketch of William Bartram. In the *New*



Courtesy of the John Bartram Association

WILLIAM BARTRAM

FROM THE PORTRAIT BY CHARLES WILLSON PEALE NOW IN INDEPENDENCE HALL

Courtesy of the John Bartram Association

A DRAWING BY WILLIAM BARTRAM

THE "SCARLET CROWNED FINCH" IS AS YET UNIDENTIFIED. THE UPPER FLOWER, "ANISUM STALLATUM," IS A SPECIES OF *Illicium*. THE LOWER PLANT, "HOUSTONIA WITH A SMALL PURPLE FLOWER," IS CORRECTLY NAMED AS TO GENUS. (ORIGINAL IN BRITISH MUSEUM.)

York Times Book Review for February 5 appeared a timely tribute by N. Bryllion Fagin, author of "William Bartram, Interpreter of the American Landscape" (1933).

In further celebration of the Bartram bicentennial, a joint meeting of the Delaware Valley Ornithological Club and the Philadelphia Botanical Club is planned for April 20 at the Academy of Natural Sciences. This appears to be the real anniversary of William Bartram's birth, rather than the commonly cited February 9.[1]

[1] According to the records of the Darby Monthly Meeting of the Religious Society of Friends, he was born on "2 Mo. 9." In the Quaker calendar of that period, this means April 9, not February 9; and April 9 (old style) is the equivalent of April 20 (new style). For this information I am indebted to Dr. Edward E. Wildman, director of science education in the Philadelphia public schools.

Both as a literary treasure and as a contribution of the first rank to American natural history and ethnology of the eighteenth century, Bartram's "Travels" (Philadelphia, 1791) was accorded immediate recognition abroad, in the shape of new editions or translations in London (1792, 1794), Dublin (1793), Berlin (1793), Haarlem (1794–97) and Paris (1799, 1801). The inspiration that Coleridge, Wordsworth and other (chiefly English) writers drew from Bartram's work is well known. An excellent summary and discussion of these literary aspects is furnished by Fagin in the work already mentioned.

As a naturalist Bartram has not lacked his critics, from his own time down to the present day. The scoffers, however, are engaged in a steady retreat, and their voices are heard less and less. Wonder-

Courtesy of the John Bartram Association

ANOTHER DRAWING BY WILLIAM BARTRAM

THE SNAKE, IN THE ACT OF SWALLOWING A FROG, IS PARTLY CONCEALED BY PLANTS. IN THE CENTER ARE TWO SNAILS (*Polygyra*) AND, TO THE RIGHT, THE LARGE FRUIT OF WATER CHINQUAPIN (*Nelumbo lutea*). ABOVE ARE A DRAGON-FLY AND A HUMMINGBIRD. (ORIGINAL IN BRITISH MUSEUM.)

fully expressive of an extreme attitude on the part of the arm-chair critics is this anonymous gem written on the flyleaf of a copy of a London edition of the "Travels" in the library of the Academy of Natural Sciences, at the conclusion of a quotation from Bartram's remarks on alligators: "Bravo Yankee Doudle this out-Herods Herod."

Probably none of Bartram's observations has been subjected to such severe and long sustained criticism as this account of the bellowing and other activities of alligators on the St. John's River. After the lapse of a century and a half, however, nearly every detail of this account has been sufficiently verified by modern eye-witnesses of these activities. As time goes on, more and more of the debated topics in Bartram become settled —or at least elucidated—in his favor.

Many of his plants and some of his animals have never been fully identified; and their proper determination constitutes one of the major remaining problems for Bartram investigators. Another is the relocation of the points of special interest visited and described by John and William Bartram, and the retracing of their routes in general through the southeastern states. Considerable progress on both lines of investigation has been made recently in eastern Georgia, and further reconnaissance along the Bartram routes throughout the Southeast is planned for the near future. Also in prospect is the publication of a lengthy and highly significant manuscript of William Bartram's which throws much new light on his published "Travels"; likewise the publication of John Bartram's diary of his 1765–66 trip (hitherto largely unpublished). The entire undertaking is being sponsored by the John Bartram Association.

It is most fortunate for students of our fauna and flora that a naturalist of William Bartram's versatility and accuracy appeared on the American scene, to become our most commanding figure in zoology, at least, during the long decades between Mark Catesby and Alexander Wilson. Certain it is that he has left us an indelible and altogether priceless record of American natural history in the eighteenth century.

FRANCIS HARPER

JAMES PLAYFAIR McMURRICH

SCIENCE in North America lost one of its most brilliant devotees recently through the sudden death of Professor James Playfair McMurrich from coronary thrombosis on February 9, 1939. Professor McMurrich possessed the qualities of true greatness and was endowed with such vigor of mind and spirit that he rose to distinguished achievement during his long and active life.

His rare ability was never used for personal aggrandizement, but only for the advancement of the science to which he was passionately devoted. Unselfishly he put forth his efforts to furthering the ultimate good of the universities, learned societies and commissions of which he was a member and leader. As a natural consequence many honors were heaped upon him, all of which he bore with becoming modesty.

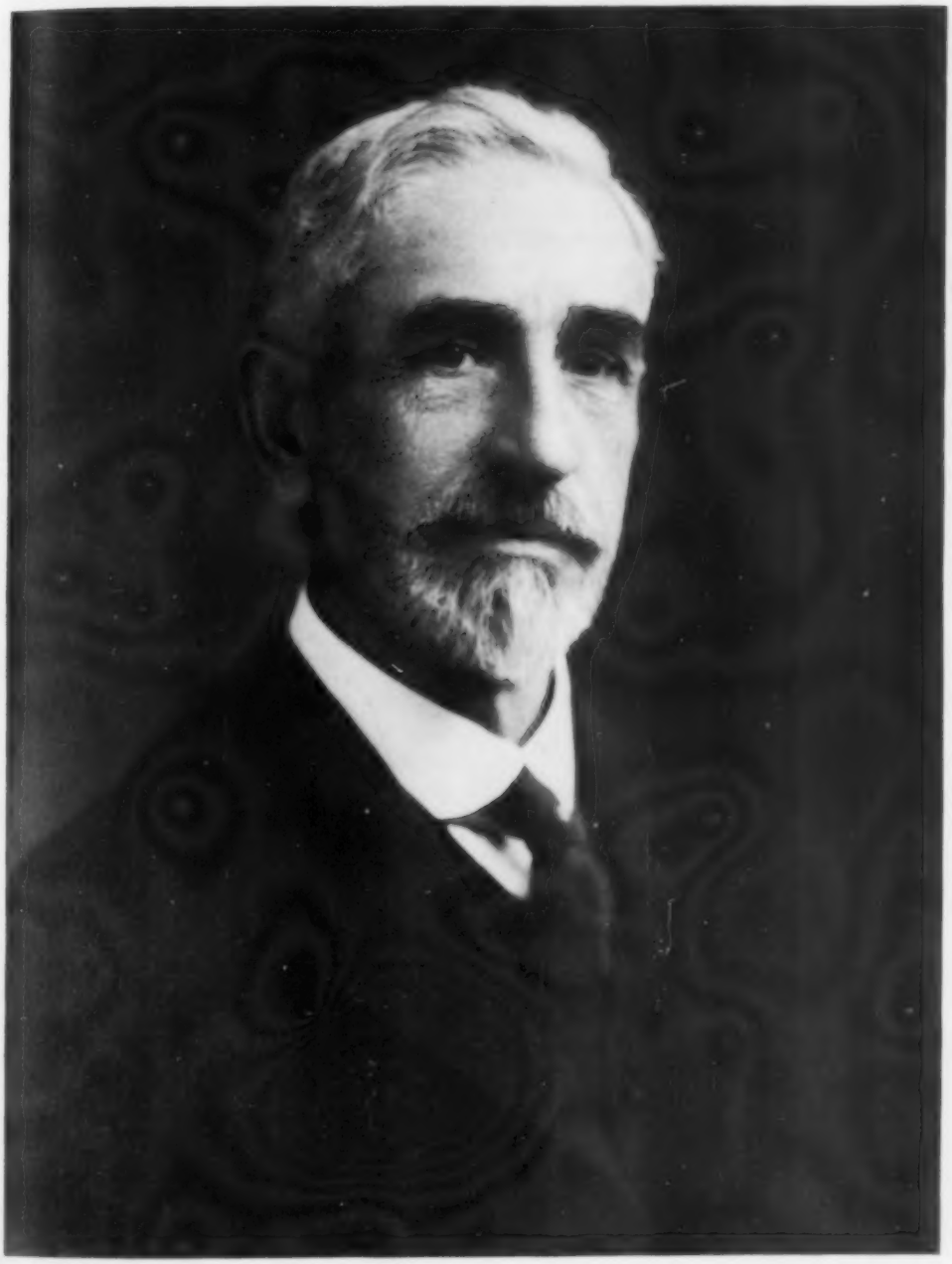
James Playfair McMurrich was born at Toronto, Canada, October 16, 1859, the youngest of eight children, his parents being the Honorable John McMurrich, M.L.C., and Janet Dickson McMurrich. His early education was at Upper Canada College. Proceeding to the University of Toronto, he graduated with the degree B.A. in 1879, some months previous to his twentieth birthday. The M.A. followed in 1881, and then at Johns Hopkins University he received the Ph.D. degree in 1885. Honorary degrees of LL.D. were later conferred upon him by the University of Michigan (1912), University of Cincinnati (1923) and the University of Toronto (1931).

The rise of Professor McMurrich in his profession was rapid, and his academic positions give evidence of his versatility and wide knowledge. The earlier posts held were: professor of biology, Ontario Agricultural College, 1882–84; instructor in mammalian anatomy, Johns Hopkins University, 1884–86; professor of biology, Haverford College, 1886–89; docent and assistant professor of animal morphology, Clark University, 1889–92; professor of biology, University of Cincinnati, 1892–94.

During these early years his fame was already widespread and brought him an invitation to become a professor of anatomy, which he refused. When, however, a second university repeated this invitation, a brilliant tribute to his powers, he felt that the call to this new sphere should be heeded, and he became professor of anatomy in the University of Michigan, 1894–1907. From there he returned to his alma mater as professor of anatomy, University of Toronto, 1907–30, which post he occupied with distinction until his retirement at age seventy as professor emeritus.

In Toronto he took a great interest in the development of graduate work and research. He was instrumental in the founding of the School of Graduate Studies, which grew rapidly under his leadership as the first dean, 1920–30, and he was active and influential in many scientific organizations.

Tall and thin in build, with a very finely formed face of highly intellectual type, Professor McMurrich gave, at first sight, an impression of physical frailty, which was deceptive, for it was compensated for by an intensely vital nervous energy. In spite of a physical discomfort from which he suffered during the greater part of his lifetime, he was capable of carrying heavy burdens, though his driv-



JOHN PLAYFAIR McMURRICH

ing zeal continually made excessive demands upon his bodily strength. He produced a total of 107 publications, including his books, "Invertebrate Morphology," "The Development of the Human Body" (seven editions), Morris' "Human Anatomy" (fourth edition), "Sobotta-McMurrich Atlas of Human Anatomy" and the section on the muscular and vascular systems in Piersol's "Human Anatomy." Another of his notable books was "Leonardo da Vinci—the Anatomist."

His truly remarkable memory, coupled with the deepest interest, made it possible for him to accumulate and retain an astounding amount of knowledge on many subjects which he was able to recall at will and use with keen insight and discrimination. As was often revealed in his conversation, his profound scholarship extended to many subjects entirely beyond his wide professional field.

As an internationally famous zoologist Professor McMurrich was chosen as the authority to whom were sent all specimens of Actinozoa collected by the Siboga deep sea expedition. Research work of some years' duration was devoted to the study and classification of these specimens. As chairman of the Biological Board of Canada and a member of the North American Committee on Fisheries Investigation for many years he traveled extensively, and in 1923 he represented Canada at the Pan-Pacific Congress in Sydney, Australia. He took keen scientific interest in fisheries, and an extensive series of papers on the salmon of the Pacific Coast climaxed his active research in this line.

For nearly thirty of his later years a major interest was the history of anatomy, which he continued to study after his retirement from the university. Many ancient books were read fluently in Greek and Latin, for Professor McMurrich desired to form his own opinions for incorporation in a reference book on the history of anatomy which he was writing and which was well advanced at the time of his death. When the Arabian period blocked his access to original sources he was undaunted, and at the age of sixty-two he learned Arabic so that he might gather his information at first hand.

He was no recluse, but occupied a high place in the social life of the community and in the esteem of his fellow men. He greatly enjoyed his various clubs and for many years was interested in the work of his church. He was very fond of travel and was an enthusiastic golfer. His life was well-rounded out and gloriously complete. He was a distinguished gentleman, scholar and scientist, admired and loved alike by colleagues, students and a host of friends.

JAMES CRAWFORD WATT, M.D.

HARD COPPER—CUPALOY

A TRADITION has come down through the ages that the ancient Egyptians knew some secret process of making copper as hard as steel. Indeed, it has often been assumed that knowledge of how to make copper tools that would cut stone made possible the construction of the pyramids. In vain the lost formula for making "hardened copper" has been sought.

Alloys of copper, tin and zinc, called bronzes, are much harder than pure copper and have been known from ancient times. But they are not "hardened" copper and, what is more important, they lack important properties of copper, such as high conductivities for heat and electricity. Just as scientists were reaching the conclusion that hard copper is a myth, the metallurgists of the Research Laboratories of the Westinghouse Electric and Manufacturing Company produced a copper alloy that has not only the hardness ascribed to the hard copper of the Egyptians but also other very desirable properties. There is not, however, the slightest probability that the ancients had this recently produced alloy.

The new hard copper, known as Cupa-

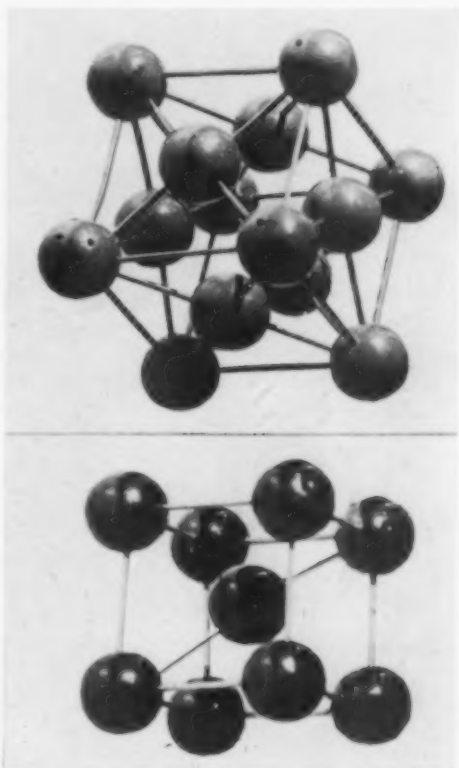
CRYSTALLINE METAL

PLASTICALLY DEFORMED, IN WHICH THE SLIP PLANES APPEAR AS STRAIGHT LINES. (BRACE.)

loy, is an alloy of about 99.44 per cent. pure copper, 0.45 per cent. chromium and 0.11 per cent. silver. After proper treatment, its hardness is about equal to that of carbon steel. In elastic limit, it also equals steel and surpasses the previous "tough pitch" hard-drawn copper about eight fold, and its "yield strength" and "ultimate tensile strength" are considerably above those of hot-rolled carbon steel. In both electrical and thermal conductivity Cupaloy has from 80 to 90 per cent. of the capacity of pure copper. Moreover, it retains these properties under prolonged temperatures up to 750 degrees F., whereas ordinary copper hardened by cold working softens in a few hours at a temperature of 400 degrees.

At once the question arises whether Cupaloy is simply a new alloy having properties interesting to scientists or whether it has valuable applications in industry. This question has been answered by Mr. P. H. Brace in a recent technical article published in the *Electrical Journal*. Among the several important uses of the alloy that he enumerates is that for welding electrodes. Since electrical welding is rapidly increasing, this use of the new alloy will illustrate why its properties are valuable. In ordinary welding the surfaces to be joined are raised in temperature to the fusing point by a blast of heat from some source, such as an oxyacetylene blow torch. In electrical welding the energy is carried to the material to be welded in the form of an electric current. It becomes heat where there is resistance to the flow of the current, namely, where the welding is to be performed.

Now why are welding electrodes of Cupaloy exceptionally satisfactory? In the first place, they hold their form under severe usage because of their hardness. In the second place, as a consequence of their high electrical conductivity, the electric energy flowing through them is not transformed in them into heat energy; it is transformed into heat in the materials having lower conductivity that are to be welded. In the next place, because of their high thermal conductivity the heat that is generated in them is rap-



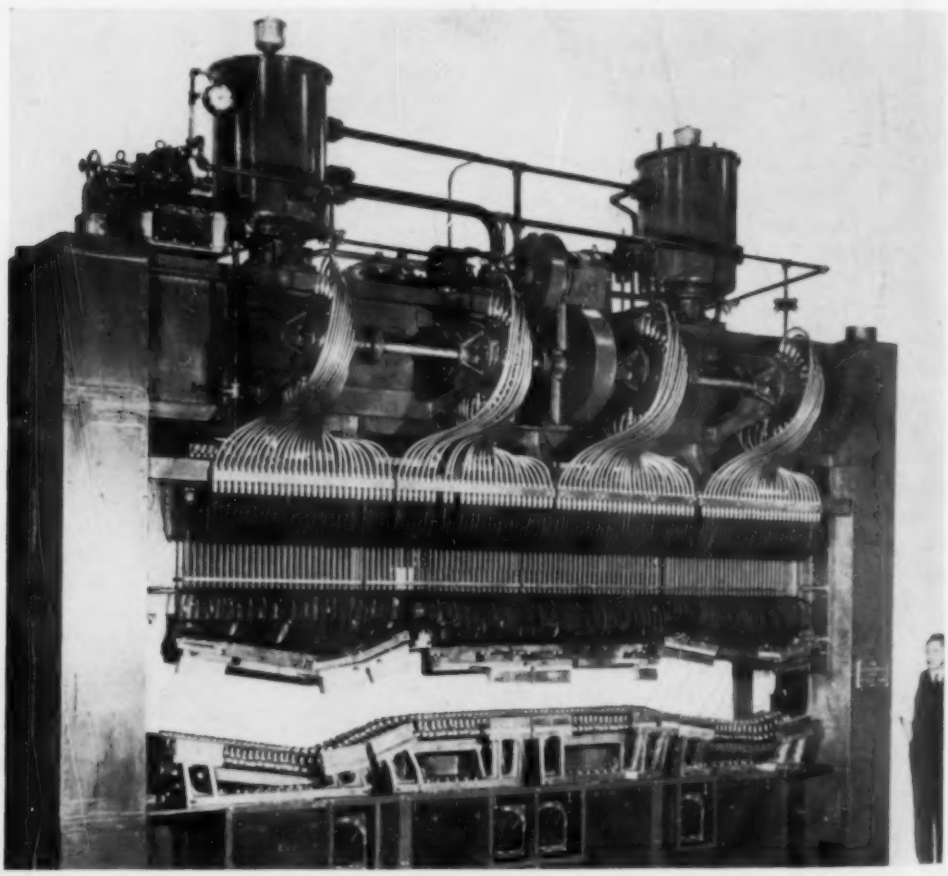
COPPER AND CHROMIUM

MODELS IN CUBICAL FORM. COPPER HAS AN ATOM AT EACH CORNER AND IN THE CENTER OF EACH FACE; CHROMIUM HAS AN ATOM AT EACH CORNER AND AT ITS CENTER. (BRACE.)

idly dissipated by conduction. Finally, they preserve all their desirable properties even under repeated and prolonged heating.

Until recently it would have been impossible to have found why Cupaloy has its remarkable properties, even if the combination of its components and the method of making it had been accidentally discovered. During recent years, however, the method of x-ray diffraction analysis of arrangements of atoms in crystals has been developed, the conclusions from which rest on the patterns of x-ray reflections by individual molecules interpreted by an abstruse theory. This remarkable and almost miraculous method reaches farther below the range of the microscope in exploring minute structures than the microscope reaches below the range of the unaided eye. For a time it was thought that the method was applicable only to regular lattice patterns. Now the theory of it has been developed to such a level that it is applicable to almost any molecular aggregation. Its promise of usefulness in exploring the mysteries of organic molecules and structural groups of molecules is almost dazzling.

Now let us return to copper and Cupaloy. It has been found that copper forms crystals out of unit "cells," as they are called, each of which is a cube with an atom at each corner and at the center of each face. Therefore, the unit "cell" contains twelve atoms in all, as is illustrated in the figure taken from Mr.

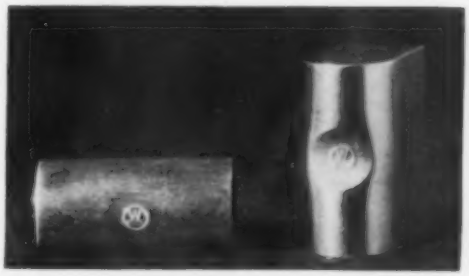


A LARGE WELDING PRESS USING CUPALOY WELDING ELECTRODES FOR THE FABRICATION OF LARGE AND COMPLICATED AUTOMOBILE FRAMES. (BRACE.)

Brace's article. The length of an edge of one of these unit cubic cells is fourteen billionths of an inch (.000,000,014 inch). In pure copper these cells are normally arranged in crystals in an orderly fashion like bricks laid in a wall. When a piece of copper is deformed these crystals slide on one another in planes without great resistance to motion, because the atomic forces are largely used up within the "cells" and the crystals.

In the case of an alloy, "cells" of different dimensions, and sometimes of different patterns, are mixed. As it happens, chromium "cells" are also cubical, but they are smaller (.000,000,011 inch) than those of copper and consist of only nine atoms, one at each corner of the cube and one at its center. The atoms in "cells" of silver are arranged like those in "cells" of copper, but they are a little larger, having edges .00,00,016 inch in length. When different kinds of atoms are properly mixed some form crystalline particles which have the effect of a roughening of the planes on which the atoms are normally arranged. The condition is somewhat like that often encountered in mechanics in which a piece of metal, called a "key," locks together two plane pieces of metal which would otherwise slip on each other.

The problem of producing alloys having desired properties is generally much more than that of finding the proper ingredients and their proper proportions. The case of copper and chromium illustrates the point. At high temperatures the two metals are in solution, a relatively uniform heterogeneous mixture. When cooled slowly the chromium atoms gradually assemble into particles. If the process continues too far, many slip planes in



THE EFFECT OF PRESSING

A ROUND BAR OF CUPALOY CARRYING AN ENGRAVED INSIGNIA AGAINST A ROUNDED PIECE OF STRUCTURAL STEEL. THE CUPALOY WAS HARDER THAN THE STEEL. (BRACE.)

the copper crystals are left unroughened because the chromium crystals are relatively few and the alloy becomes softened and weakened. The problem is to discover the sequence of temperature changes, including sudden chilling, to produce the most advantageous sizes and distribution of the various crystals.

From what has been said it might be conjectured that if 0.45 per cent. of chromium produces a given amount of hardening in the copper then a greater amount of chromium would increase the property. Such is not the case. It may appear strange that less than one-half per cent. should produce the most favorable combination of properties of hardness and conductivity. But this brief account does not include all that is known about this problem, and all that is known is only a small part of what is desired. But the success in producing Cupaloy and other recent alloys, as well as the theoretical and practical means that have recently become available, indicates that metallurgy is still in its infancy, but that it gives promise of a rapid development and a glorious future.

F. R. MOULTON

"INFERIOR" CHILDREN IN SUPERIOR HOMES

EXPERIMENTS undertaken to assess the hereditary factors in sub-normal intelligence continue to give perplexing results. One of the latest of these is a study of 16 children of feeble-minded mothers who were placed in good foster homes shortly after birth, which is reported to the Society for Child Development of the Na-

tional Research Council from the State University of Iowa.

All these children are developing up to the normal level, according to Marie Skodak, of the university staff, who conducted the experiment.

The fathers of these children also were known and in nearly every case were worthless individuals. Both mothers and fathers, Miss Skodak says, "came of families distinguished for long records in welfare offices even during predepression years and for familiarity with various state and local penal, mental and charitable institutions."

All the babies were taken away from their mothers before they were 3 months old and placed in carefully selected middle-class homes. All were given standard intelligence examinations at two and a half and four and a half years. Miss Skodak expected that they would show up quite poorly. To the contrary they showed intelligence quotients almost identical with the average for children of the same ages.

The point has been raised, she says, that the mental development of these children will slow up rapidly as they enter adolescence so that they will revert nearly to the feeble-minded level when they are about 16. There is no evidence, she claims, for such sudden declines.

"The general conclusions which may be drawn from these results," she reports, "are that children of feeble-minded mothers and grossly inferior family background, when placed in average or superior foster homes at an early age, are indistinguishable in mental development from children whose mothers are not feeble-minded. The results indicate that if a child is physically normal and if the placement is made at so early an age that the child experiences only the environment of the foster home, the mental state of the mother ought to be no bar to adoption in a permanent foster home."

THOMAS HENRY

SLEEP LONGER

A TWO-HOUR nap may add as much as half an inch to a child's stature. This phenomenon, demonstrating the semi-elasticity of the human body, is reported to the Society for Child Development of the National Research Council by Drs. Janet M. Redfield and Howard V. Meredith, of the State University of Iowa. They made exact measurements on 22 children, 4 and 5 years old, in the university's nursery school.

The children had a rest period every afternoon. Some fell asleep regularly, while others lay awake on their cots. Both groups showed increases in stature, with the sleepers far in the lead. The average gain for the slumberers, they report, was a trifle less than half an inch, and almost 90 per cent. of this gain was between the hips and top of the head. Those who did not sleep gained about a quarter inch for each rest period.

The phenomenon is explained, they believe, by the constant pressure on the tissues of the body. The ribs constantly are being pressed closer together by the weight above them. This is especially true during vigorous play when the tissues are "shaken down." When the body is recumbent all this pressure is released, and the naturally elastic body returns to its greatest length. The explanation for the increased growth during sleep is that there is almost complete relaxation and hence no muscular resistance to the snap back.

Hitherto gains in height during sleep have been reported for individuals, chiefly adults. Some German investigators have found increases of almost an inch in adolescents.

The gains registered by the Iowa children, it was found, nearly all disappeared during the first two hours of play after their naps.

THOMAS HENRY